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THE COLD LAKE OIL SANDS PROJECT: AN ECONOMIC ANALYSIS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "The Cold Lake Oil Sands Project: An Economic Analysis," submitted by Alan Michael Dooley in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

The Cold Lake oil sands project, if undertaken, will be the first *in situ* petroleum extraction development of commercial size of its kind. At full capacity the project is expected to add 140,000 barrels per day to Canada's petroleum production. As production of conventional crude declines, oil from the large oil sand deposits in Alberta may be necessary if the national goal of energy self-sufficiency is to be met. The present study examines the economic viability of the proposed $9 billion project. The study stresses both qualitative and quantitative forms of analysis. In particular, emphasis is placed on economic efficiency and on the potential impacts of the project on the resource uses which presently play an important role in the regional economy. A benefit-cost analysis framework is the methodology used in the study.

Results of the study indicate that at current world prices for oil, the discounted tangible benefits of the development far exceed the discounted tangible costs. That is, the gainers from project go-ahead could presumably compensate the losers and still remain better off. Intangible costs would have to be great to warrant a total rejection of the project on purely economic grounds. At a price per barrel of $25.00 ($1979), the project was determined to

generate an internal rate of return of approximately 18 percent in real terms.

Recent petroleum discoveries in the so-called frontier regions of Canada suggest the possibility of premature oil sands development. Whether or not such is, in fact, the case will depend on the size and, hence, the per barrel extraction costs of these oil pools.

There appears to be some need for the public sector to take greater initiative regarding involvement in project economic analyses where public investment is anticipated. As private and public interests may diverge due to spillover or distributional effects, a more active role by government would seem to be in the best interests of Canadians.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Background to the Study

Since the OPEC oil embargo of 1973, North Americans have become aware of their dependence on foreign suppliers of crude oil. OPEC's ability to influence both supply and price has placed consuming nations in a vulnerable economic position. To reduce dependence on the OPEC nations, the governments of both Canada and the United States have initiated steps toward achieving energy self-sufficiency by the 1990's. Meeting that goal is expected to require more strict energy conservation guidelines, increased reliance on traditional energy sources such as coal, and the development of unconventional energy sources such as oil sands and shales, solar power, and nuclear energy.

Since the 1947 discovery at Leduc, Alberta has been the dominant petroleum producer in Canada. Between 1973 and 1978 annual marketable crude production in Alberta fell from 522 million barrels to 377 million barrels.[1] Evidence suggests that in the absence of a major new discovery, production in that province will continue to decline. The

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[1] Statistics Canada. The Crude Petroleum and Natural Gas Industry. Catalogue Number 26-213, various years.

growing gap between consumption and domestic production is expected to be met in part by increased production from the large oil sands deposits located in east-central Alberta. The four major deposits combined cover an area of 22,000 square miles and are estimated to contain one trillion barrels of bitumin in-place.[1] Development of a portion of the Cold Lake deposit has been proposed. The developer, Esso Resources Canada Limited (Imperial Oil), expects that production of upgraded crude could begin by 1986 or 1987. Construction should begin sometime after a new federal-provincial energy agreement has been reached and appropriate fiscal arrangements with the company have been made.

Problem Statement

In Canada, the development, transportation, and marketing of petroleum resources has generally been left to the private sector. Public involvement has tended to be regulatory in nature (taxation, royalties, export controls, etc.). A more efficient allocation of resources is thought to occur when left to a freely operating market. Government interference is warranted only when spillovers or distributional effects are more important than efficiency considerations.

Considerable government involvement is anticipated for the Cold Lake oil sands project, both direct and

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[1] Alberta Energy and Natural Resources. Alberta Oil Sands Facts and Figures, 1979, p. 1.

indirect. Direct involvement will include the various publicly provided infrastructure such as roads, hospitals, and schools. Indirectly the government will influence the project through tax and other measures.

The present study is concerned with the imbalances in information that can exist between the private and public sectors and the possible effects of such imbalances on the decision-making process. In the context of the Cold Lake oil sands project, both the commercial viability and the social economic analysis of the development have been provided by the developer.[1] Economic input from the public sector appears to be deficient. Where the interests of the public and private sectors are identical, public economic input may be unnecessary. If interests diverge because of spillover or distributional considerations, some involvement by the public sector may be warranted.

Can a private entity be expected to impartially trade off its best interests with those of the rest of society? One might expect the developer (or firms employed by the developer) to reach conclusions consistent with private goals. Where large public involvement in infrastructure and concessions in one form or another are anticipated, it may be desirable for a publicly sponsored economic evaluation. In that way the interests of society can be

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[1]See Foster Research Ltd., Cost-Benefit Analysis of the Cold Lake Oil Sands Project, Calgary, 1978.

adequately represented.

The present study attempts to provide a more thorough look at the possible outcomes of the Cold Lake oil sands project by applying a number of different assumptions and using the most recent information available.

Objectives of the Study

The objectives of the study are to:

1. Introduce a conceptual and practical framework for examining and comparing alternative resource use patterns;
2. Identify and analyze the important issues relating to the Cold Lake project;
3. Quantify the resource uses presently found in the development region (the gains or losses from a change in resource use mix can then be more readily identified); and,
4. Present a number of alternative benefit-cost scenarios based on more recent information and some different assumptions. The benefit-cost approach is a commonly used method for selecting among alternative resource uses.

Outline of Chapters

In Chapter II an overview of the proposed Imperial Oil development and the Cold Lake regional economy is presented. Chapter III begins by introducing a conceptual framework for analyzing and comparing resource uses. The chapter ends with a theoretical discussion of the benefit-cost procedure and the benefits and costs of the Cold Lake project as determined by Foster Research. Chapter IV provides a number of benefit-cost evaluations of the Cold Lake oil sands project under a variety of price and discount rate assumptions. In addition, the anticipated impacts of the development on other resource uses in the region are examined. Chapter V consists of a summary and conclusions, as well as some policy implications.

CHAPTER II

COLD LAKE: THE OIL SANDS PROJECT AND THE REGIONAL ECONOMY

The Oil Sands Project

On November 7, 1977 Imperial Oil Limited applied to the Energy Resources Conservation Board (ERCB) for approval of a scheme to produce and upgrade bitumin from their oil sands lease in east-central Alberta. The proposed project will be located approximately 11 km from the town of Cold Lake. The entire development area occupies 143 km^2 (see Map 1 - Appendix A).

Unlike the oil sands deposits near Ft. McMurray, the Cold Lake deposits are buried under 1000 to 2000 feet of overburden, making surface mining impractical. Imperial Oil has developed an *in situ* recovery process using steam injection to overcome the problem. Experiments indicate that a one month period of high pressure steam injection followed by a soak period will allow wells to produce for three to six months. Total recovery over the project life is estimated to be 1.46 billion barrels of bitumin or approximately 20 percent of the estimated in-place reserves.

Approximately 980 wells will be drilled at the start of the project, with 350 being added each year to

offset the declining productivity of preceding wells.[1] Over the 25 year expected life of the project, Imperial estimates that 8300 wells will be required. Wells will be drilled in clusters of twenty wells per pad. To allow centralization of surface facilities, individual wells will be drilled at angles. Directional drilling will allow recovery from a large area with relatively little land surface disturbance. Imperial estimates that their approach will require one-quarter of the land area necessary when wells are vertically drilled.

Other than the basic production facilities, the development will include facilities to produce upgraded light crude and a steam generation and utilities complex. The upgrading process involves two basic steps: (a) carbon removal and (2) hydrogen addition. The carbon removal process chosen for the Cold Lake project is known as Flexicoking. The process converts the bitumin to light products and gas. Carbon removal is in the form of coke. The liquid products from the Flexicoking process then undergo hydrogen addition or hydrotreating. Hydrotreating removes sulphur and nitrogen while stabilizing the products. Sulphur recovery facilities will be required. Alberta guidelines require that such facilities be at least 98 percent efficient.[2]

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[1]Esso Resources Canada Limited. Final Environmental Impact Assessment, Vol. I, Project Description, 1979, p. 5.

[2]Estimates are that the two percent unrecovered will amount to 31 tons/day of elemental sulphur.

The steam generation/utility facilities include steam generation, water supply and treatment, electrical, and other facilities (sewage treatment and disposal, fire fighting, etc.).[1] Electrical power requirements will be purchased from the provincial grid system.

Large volumes of water will be required for steam generation. Imperial Oil selected Cold Lake as the preferred source for the 584 thousand barrels of fresh water needed per day. Cold Lake was ideal from the developer's point of view because of its close proximity to the development and low levels of dissolved solids. The ERCB decision of 1979 recommended that the North Saskatchewan River be used as the fresh water source. The Board cited possible adverse effects from such large withdrawals from Cold Lake as a main objection.

Natural gas was the preferred balancing fuel for steam generation. In the ERCB decision the recommendation was that coal be used.

> The Board considers the natural gas alternative to be an inappropriate use of a high value energy resource and in view of the overall marginally greater benefit associated with the coal alternative, believes this to be most appropriate makeup fuel.[2]

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[1]Esso Resources Canada Limited. Final Environmental Impact Assessment, Vol. I, Project Description, 1979, p. 19.

[2]Energy Resources Conservation Board. In the Matter of an Application of Esso Resources Canada Limited, Under Section 43 of the Oil and Gas Conservation Act and Section 27 of the Coal Conservation Act. Calgary, Alberta, 1979, p. 76.

Additional off-site facilities include a pipeline to carry upgraded crude from the development site to the Edmonton area, a waste water pipeline from the upgrader facilities to the Beaver River, a fresh water pipeline to the North Saskatchewan River, and either a rail system or a slurry pipeline to transport the 1.3 million tonnes of coal per year required for steam generation. The coal is expected to be extracted from deposits near Judy Creek.

Employment Impacts

The Cold Lake oil sands project will create a considerable number of jobs in the region. During the five-year construction phase, an estimated average of 5000 workers will be required. The majority of these positions will be taken by skilled tradesmen such as plumbers, welders, millwrights, and carpenters. A breakdown of employment during the construction phase is shown in Table 2.1. Once in operation the project will create approximately 2000 permanent jobs: 1200 skilled, 200 clerical, and 600 engineering.[1] Secondary employment effects, especially in the service trades, are anticipated.

The Cold Lake Regional Economy

The economy of the Cold Lake region historically has been agricultural. Farming settlements which began in the early 1900's provided the base from which the region's

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[1]Foster Research, Cost-Benefit Analysis of the Cold Lake Oil Sands Project, Calgary, Alberta, 1978, pp. IV-24.

Table 2.1

Estimates of Construction-Phase Employment

Type of Labour	Man-Years	Months Duration	Ave. Employment	Peak Required	
				Persons	Timing
Manual	18,680	63	3,560	7,900	3Q 1984
Non-Manual	7,690	63	1,465	2,750	2Q 1983
Total	26,370	63	5,025	9,970	3Q 1983

Source: Foster Research. Cost-Benefit Analysis of the Cold Lake Oil Sands Project, 1978.

towns and villages have developed. The first established community in the area was Bonnyville which became the service centre for the agricultural industry.

The second stimulus to growth came in 1952 with the establishment of Canadian Forces Base (C.F.B.) Cold Lake at Medley. The Base contributes about $50 million annually to the economy of Alberta, much of which is spent in the Cold Lake area, albeit mainly for items imported into the region.[1]

Agriculture

Over the long term agriculture has and will likely continue to be the most important activity in the area. While petroleum exploration and development may overtake the traditional agricultural sector in importance if the Cold Lake development is undertaken, the physical limitations of the resource make the petroleum industry relatively transient in nature.

The greatest constraint on agricultural production in the area is climate. Long winters and warm, short summers limit crop selection. The frost-free period ranges from 70 to 80 days, with annual precipitation in the 40 to 45 centimetre range. Soils are of the dark grey wooded and grey wooded types with Canada Land Inventory (C.L.I.) ratings in the four to six range predominating.

The number of farms and farmers in Alberta has been

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[1] Alberta Municipal Affairs. Cold Lake Oil Sands Subregional Study (Edmonton: Alberta Municipal Affairs, 1978), p. 30.

declining steadily.[1] Over the four census periods 1961 to 1976 farm numbers have fallen from 73,212 to 57,310.[2] Census division twelve (C.D. 12), which includes the proposed development area (see Map 2 - Appendix A) shows a similar trend. Over the same period farm numbers in C.D. 12 declined from 4,494 to 3,144. However, farm size has been increasing. In 1976 the average farm size in C.D. 12 was 746 acres, up from 615 acres in 1961. An average farm in the province was 864 acres in 1976 or about 15 percent larger. Nevertheless, relative to the rest of Alberta, farms in C.D. 12 are small. This size difference is true whether the comparison is in terms of acres, value of farm holding or value of sales.

In 1976, 39 percent of farms in C.D. 12 were less than 400 acres, as compared with 40.2 percent for the province as a whole. The large number of small farms is related to Statistics Canada's definition of a farm. For farms of 1600 acres or greater the figures are again comparable; 7.2 percent of C.D. 12 farms and 10.4 percent of Albertan farms fall into that category. The preceding indicates wide variation in the size of farm holding within C.D. 12 and throughout Alberta.

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[1] Much of what follows has been derived or taken from Canada census data 1961-1976.

[2] The definition of a census farm was changed in 1976 from an agricultural holding of one acre or more with sales of $50 or more to a holding of one acre or more with sales of $1200 or more.

The dominant form of production in both C.D. 12 and Alberta is cattle (beef) production, with 49.3 percent and 37.5 percent of all farms, respectively, so classified. Small grain production is the next most important farm enterprise classification, comprising 23.5 percent of C.D. 12 farms and 28.3 percent of all farms in Alberta. A breakdown of the farm value of some major commodities is provided in Table 2.2. With a few exceptions, C.D. 12 accounts for a relatively small percentage of the value of most major agricultural products (last column, Table 2.2).

As a source of employment, agriculture appears to be of greater importance to C.D. 12 than to the province as a whole. In 1971, 24.2 percent of the total labour force of C.D. 12 was engaged in agriculture. Only 14.1 percent of the provincial labour force was so employed at that time. Despite a relatively smaller scale of operation in C.D. 12, agriculture is more dominant in the regional economy.

When compared in terms of value of agricultural sales, farms in C.D. 12 tend to be below provincial averages. In 1966, two percent of farms in C.D. 12 had sales exceeding $15,000 as compared with 14.3 percent of all Alberta farms. By 1976, 23 percent of C.D. 12 farms and 47.6 percent of all farms in the province had agricultural sales exceeding $15,000; 22.2 percent of farms in Alberta and 37.2 percent of farms in C.D. 12 had agricultural sales of less than $5000 in 1976.

Table 2.2

Farm Value of Major Agricultural Products
for 1976 - C.D. 12 and Alberta

Commodity	Census Division 12 ($\$ \times 10^6$)	Alberta ($\$ \times 10^6$)	Census Division 12 as a percent of Alberta
Field Crops - wheat	$ 8.6	$ 542.4	1.6%
- oats for grain	8.3	143.1	5.8
- barley for grain	13.7	487.6	2.8
- rapeseed	2.3	103.1	2.2
- tame hay	23.7	256.5	9.2
Livestock - cattle	11.2	617.9	1.8
- calves	1.6	19.0	8.4
- hogs	5.1	127.8	4.0
- sheep and lambs	.1	3.7	2.7
Dairy	6.1	123.7	4.9
Poultry and Eggs	2.5	67.4	3.7
Total Major Commodities	$83.2	$2492.4	3.3%
All Other	--	154.2	
Total Farm Value of Agricultural Products	$83.2	$2646.6	

Source: Resources Management Consultants. Draft Final Environmental Impact Assessment, Vol. II, Socio-Economic Impact Assessment, p. 40a.

The capital values of census farms in C.D. 12 again appear lower than their provincial counterparts. In 1971, 17.1 percent of all farms in C.D. 12 had a capital value of less than $14,950 as compared to 8.5 percent of all provincial farms. By 1976, only two percent of farms in C.D. 12 had a capital value under $14,950, but only .76 percent of all Albertan farms were in this same category. In 1976 89.3 percent of farms in Alberta and 77.5 percent of farms in C.D. 12 had capital values exceeding $49,950.

Table 2.3 shows the breakdown of income by source for farmers in Alberta and C.D. 12 in 1974. Farmers in C.D. 12 appear to depend on off-farm employment to maintain income levels far more than farmers throughout the province on average. Average net farm incomes for farmers in C.D. 12 were approximately 15 percent of the provincial average. Total average net incomes in C.D. 12 were just 50 percent of provincial averages.

Farms in C.D. 12 are not distributed evenly throughout the division. A large proportion (75 percent in both 1971 and 1976) are located at the extreme south near the Imperial Oil oil sands lease in the counties of St. Paul, Smoky Lake and Bonnyville. Of the 10,294 people on farms in C.D. 12 in 1976, 7,722 lived within these three counties. The impact of road and pipeline construction, noise, and emissions of sulphur and fly ash will be of greater importance in the immediate vicinity of the proposed development than for C.D. 12 as a whole.

Table 2.3

Incomes of Farmers 1974 -
C.D. 12 and Alberta

	Census Division 12	Alberta
Farm Income		
Number of Farm Tax Filers	3,287	82,233
Total Net Farm Income	$ 2 x 10^6	$353.5 x 10^6
Average Net Farm Income	$ 614	$ 4,299
Off-farm Income		
Number of Tax Filers	3,001	77,959
Income	$13.8 x 10^6	$476.9 x 10^6
Average Net Income	$ 4,586	$ 6,117
Total		
Total Net Income for Farm Tax Filers	$15.8 x 10^6	$830.4 x 10^6
Average Net Income	$ 5,200	$10,416

Source: Resources Management Consultants. Draft Final Environmental Impact Assessment, Vol. II, Socio-Economic Impact Assessment.

Commercial Fishing

A recent study done by Alberta Department of Municipal Affairs found that only 283 of the 1976 study area population of 20,118 derived income from fishing.[1] The industry appears to neither provide a source of full-time employment for participants nor generate adequate incomes for them. The impact of commercial fishing in both the economy of Alberta and the Cold Lake region seems insignificant.

There are eight commercial fishing zones in Alberta (A-H). Zones C, which includes the development region (see Appendix A - Map 3), D, and E account for over 50 percent of commercial fish production in Alberta. Other than the licenses issued to native fishermen, two main types of commercial licenses are available: (a) zone commercial licenses and (b) zone fisherman licenses. A zone commercial license allows the fisherman to fish any lake in a particular zone. Zone fisherman licenses are specific to individual lakes. The major species harvested are tullibee, pike, and whitefish. Of lesser importance are suckers, perch, ling, lake trout and walleye. Table 2.4 provides some indication of the monetary importance of commercial fishing to the development area.[2]

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[1] Alberta Municipal Affairs. Cold Lake Oil Sands Subregional Study (Edmonton: Alberta Municipal Affairs, 1978), p. 28.

[2] For a breakdown of fish harvests by major lake and species, see Appendix A - Tables A.1.1 - A.1.7.

Table 2.4

Weight and Value of Catch to Fishermen from Zone C

Year	Zone C Weight (lbs)	Zone C Value ($)
1969-70	1,077,000	140,000
1971-72	532,000	129,000
1973-74	738,000	160,000
1975-76	690,000	207,000
1976-77	715,000	233,000

Source: Resources Management Consultants. Draft Final Environmental Impact Assessment, Vol. II, Socio-Economic Impact Assessment.

Table 2.5

Numbers Employed in Fishing and Trapping - Alberta and C.D. 12

		Labour Force			
Year	Total Alberta	Total C.D. 12	Fishing and Trapping Alberta	Fishing and Trapping C.D. 12	Fishing and Trapping as a % of Total Employment in C.D. 12
1961	489,511	15,728	839	259	1.6
1971	688,280	19,220	230	65	.3

Source: 1961 and 1971 Census of Canada, Catalogue Numbers 94-502 and 94-718.

Trapping

Trapping does not appear to be of great importance to the economy of C.D. 12 or Alberta. As employers, both fishing and trapping account for only a small percentage of total employment in C.D. 12 (see Table 2.5). The movement out of fishing and trapping during the 1961 to 1971 period likely reflects the difficulty of participants in maintaining adequate incomes.

The value of pelts harvested in Alberta has risen steadily over the period 1969 to 1977. From a value of $1.57 million in 1969-70, the value of pelts harvested had reached over $7 million by 1976-77. Much of the increase was a result of higher pelt prices rather than larger catches.[1] The trend of rising pelt prices has continued through to the 1978-79 trapping season.[2]

By numbers of harvested species, squirrel, muskrat, beaver, mink, and coyote predominate. By value of pelt, the long-haired furbearers such as coyote, lynx, and beaver are of greater importance. Imperial Oil Limited estimates that the cash value of pelts harvested on the development lease over the period 1972 to 1978 has ranged from a low of $6,210 in 1973-74 to a high of $18,540 in 1972-73. The 1976-77

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[1]Resources Management Consultants. Draft Final Environmental Impact Assessment, Socio-Economic Impact Assessment, Vol. II, p. 57.

[2]For average pelt prices over the 1975-76 to 1978-79 seasons, see Appendix A - Table A.2.

harvest was estimated to be $16,800.[1] Over the 1971 to 1975 period the estimated annual values of catch per active trapline was $4,600 for the study area and $3,038 for Alberta as a whole. Like commercial fishing, trapping appears to provide only seasonal employment for most participants.

Recreation

Alberta is divided into fourteen recreation zones. Lakeland (see Appendix A - Map 4) which encompasses the development area, accounts for a disproportionately large share of the province's high capability recreational shorelands. In Table 2.6 the province is divided into ten lake regions.[2] Region four, Lakeland, is presently underutilized.

In 1976, visitors to Lakeland spent $4.6 million. Expenditures by residents of the zone are unavailable. The proximity of the Edmonton area and the increasing demand for recreation is expected to result in increased user pressure on the zone's recreational resources, with or without the Cold Lake development.

Oil and Gas

Until recently, oil and gas development have played a minor role in the economy of the area. Natural gas from fields in the area has been sufficient to meet local demand.

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[1]Esso Resources Canada Limited. Final Environmental Impact Assessment, Vol. III, Socio-Economic Impact Assessment, 1979, p. 63.

[2]These lake regions were identified in the Alberta Land Use Forum and are not identical to the recreation zones as identified by Travel Alberta in Appendix A - Map 4.

Table 2.6

Comparative Rating of Lakes for Recreation by Region

Region Name and Number	General Supply	Amount of Real Supply	Quality of Supply	General User Pressure Relative to Real Supply
1) Canadian Shield	High	Low	High	Low
2) Northern Boreal Forest	Moderate	Low	Moderate	Low
3) Peace River	Moderate	Moderate	Moderate	Moderate
4) Lakeland	High	High	High	Low
5) Edmonton Aspen Pklnd.	Moderate	Moderate	Moderate	High
6) Eastern Aspen Pklnd.	Moderate	Moderate	Moderate	Moderate
7) Red Deer	Moderate	Moderate	Moderate	High
8) Calgary Prairie	Low	Low	Low	High
9) Short Grass Prairie	Low	Low	Low	High
10) Rockies and Foothills	Moderate	Low	Moderate	Moderate

Source: Alberta Land Use Forum: The Use of Our Lakes and Lake Shorelands, 1974, pp. II-36.

Estimated in-place gas reserves for the region are 103 billion cubic feet.[1] Conventional oil production is insignificant. Of the two fields in the area, one has been partially abandoned since 1961, the other has been abandoned since 1968.

Knowledge of the oil sands has existed for over a hundred years. Real interest in them as a viable energy source is relatively recent. Today the oil sands comprise the area's most important nonrenewable resource. Proven reserves of the Cold Lake deposit are estimated to be 165 billion stock tank barrels.

The Imperial Oil development would be the first operation of commercial size on the Cold Lake deposit. Interest in the oil sands has also been shown by Norcen Energy, British Petroleum, Chevron, Gulf Oil, Worldwide Energy and Union Texas. These operations remain in a pilot plant stage however.

Evidence indicates that of the resource uses presently existing in the Cold Lake area, agriculture is of greatest economic importance, particularly as an employer. Fishing and trapping appear to be part-time or seasonal sources of employment for most participants. Potential does exist for increased economic activity in the developing recreation industry. Should the Cold Lake project be undertaken, petroleum development will play a much greater role in the regional economy.

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[1] Ibid., p. 71.

CHAPTER III

CONCEPTUAL AND APPLIED APPROACHES TO EXAMINING RESOURCE USE

In Chapter II the economic activities currently existing in the Cold Lake area were identified and discussed. Agriculture, the military, and to a lesser extent, trapping, commercial fishing, and recreation are important presently. The Cold Lake oil sands project, if undertaken, would be added to the list of current and potential resource uses.

In this chapter a conceptual framework is developed within which resource uses can be viewed. A theoretical framework provides a useful benchmark for measuring gains or losses when a change in resource use is being considered. In the remainder of the chapter benefit-cost analysis (BCA) is discussed. The BCA discussion will introduce some of the theoretical foundations of the procedure and identify the benefits and costs of the Cold Lake oil sands development.

Allocating Resources Among Alternative Uses

Resource uses can be complementary or competitive with one another. Complementarity occurs when an increase in one resource use increases the productivity of a second. Resource uses are competitive when an increase in one use reduces the productivity of a second. The issue of resource use compatibility has been addressed in the literature recently. De Pape *et al.*[1] argue that resource use compatibility should be viewed both in terms of purpose and of use. To clarify, resource use categories may demonstrate a compatibility in purpose and at the same time an incompatibility in use. For example, the roads and access routes to the oil sands project may encourage increased activity by the area's hunters and fishermen. To that extent the uses of the roads are compatible in purpose. Should increased access and traffic disrupt wildlife habitat, the activities can be considered incompatible in use. A resource use compatibility matrix has been developed for the project area (see Appendix B - Table B.1). While providing no definite answers, one can see that the various resource uses cannot be viewed in isolation. Tradeoffs may be required. The complementarity-competitiveness question has two dimensions. One is concerned with different possible resource uses; the second relates to resource use over time and the notion of user cost (to be

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[1] D. De Pape *et al.* A Socioeconomic Evaluation of Inuit Livelihood and Natural Resource Utilization in the Tundra of the Northwest Territories. Vol. 4, Renewable Resource Studies. Inuit Tapirisat of Canada, July 1975, pp. 18-25.

discussed later).

Pearse[1] suggests a marginal analysis type of approach for choosing an optimal resource use mix. Simply stated, the decision criterion calls for resources to be allocated among possible resource uses to the point at which the value added from resources being shifted to one use is equal to the value lost from the removal of resources from a second use.[2] Stated somewhat differently, the condition requires a resource use mix which maximizes the discounted stream of net social benefits. Net social benefits are determined by taking the difference between social benefits and social costs. A distinction is made between 'social' and 'private'.benefits and costs because social accounting requires that all costs and benefits be considered, regardless of incidence. Discounting allows for a comparison of benefits and costs as they arise over time.

There are difficulties in selecting an optimal resource use mix. Some are market related; others arise due to the nature of the resource use itself. Most resource uses produce goods or services which are exchanged in the marketplace. The price is said to reflect consumers' willingness to pay and can be used as a proxy for the 'value' of the resource. Where the resource is used as an

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[1] P.H. Pearse. "Principles for Allocating Wildland Among Alternative Uses," Canadian Journal of Agricultural Economics, Vol. 17, 1969, p. 125.

[2] In practice this optimum may be unachievable. However, if a use change adds more to benefits than to costs, an optimum can be approached.

input in the production of some final good (e.g., oil in the production of gasoline), the demand for the resource is a derived demand. The correct value of such a resource is the value of the final output less the value of any necessary inputs other than the intermediate product.

Where markets are absent, valuation problems arise. Some resource uses such as sightseeing, hiking, or sport fishing and hunting are not usually traded in the market (although license fees may partially capture benefits). Evaluating these types of resource uses is difficult. Valuing them at zero would be inappropriate as demand does exist and could presumably command some price if a market did exist. Attempts have been made to measure the benefits generated by these resource uses.[1] More work in the area is still needed.

Even where no demand currently exists, a resource use may have value. The argument is that some people place a value on knowing that a resource exists whether or not they may ever see or use it. An example of this so-called existence value is the interest in preserving certain wildlife and marine species. Natural scenic attractions may fall into the same category.

Another type of market failure results from the presence of externalities. Externalities or spillovers are

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[1]See for example, J.V. Krutilla and A.C. Fisher. The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources (Baltimore: The Johns Hopkins University Press, 1975).

those benefits or costs imposed by one production or consumption unit on another. With no market mechanism to induce compensation, output of the resource in question will diverge from optimality. An example relevant to the Cold Lake oil sands project would be the release of sulphur dioxide (SO_2) into the atmosphere from the bitumin upgrading facility. The air is treated as a free good and will be used as long as a positive marginal product (MP) results. Over time, the buildup of sulphur in the soil may reduce agricultural productivity in the area. Either the polluting firm should be made financially responsible for these emissions or, alternatively, the public could pay the firm not to pollute. If not, one would expect output to be greater than would be the case if all costs, private and social, were taken into account.

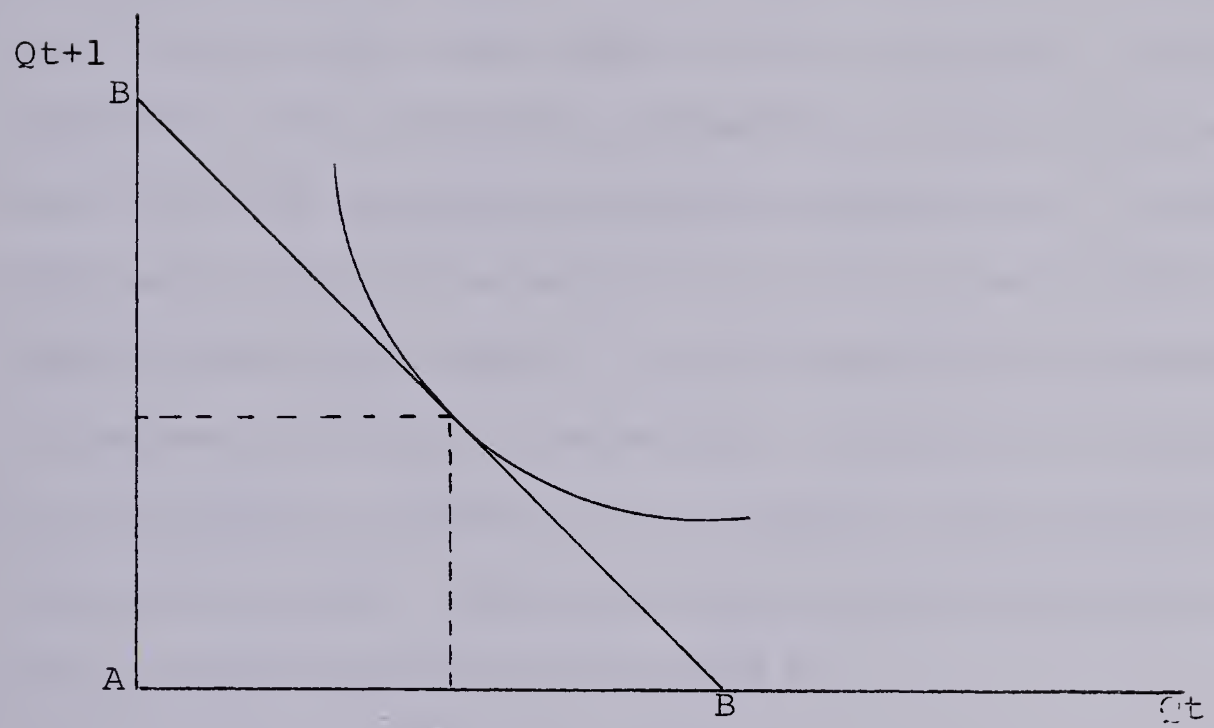
Resource uses which are 'lumpy' make an optimal use mix difficult to achieve. Some resource uses, such as the building of a pipeline to move upgraded crude from the oil sands development to Edmonton, can either be undertaken or not. Marginal changes in resource uses will be precluded under these circumstances. Similarly, irreversibilities arising from particular resource uses make it impossible to respond to changing relative price conditions. Once undertaken, alternatives are foregone forever.

Economics of Non-Renewable Resources

The destructibility of certain resources results in an economic (and moral) problem concerning the rate at which resources should be used over time. Figure 3.1 provides a

Figure 3.1

Intertemporal Resource Allocation



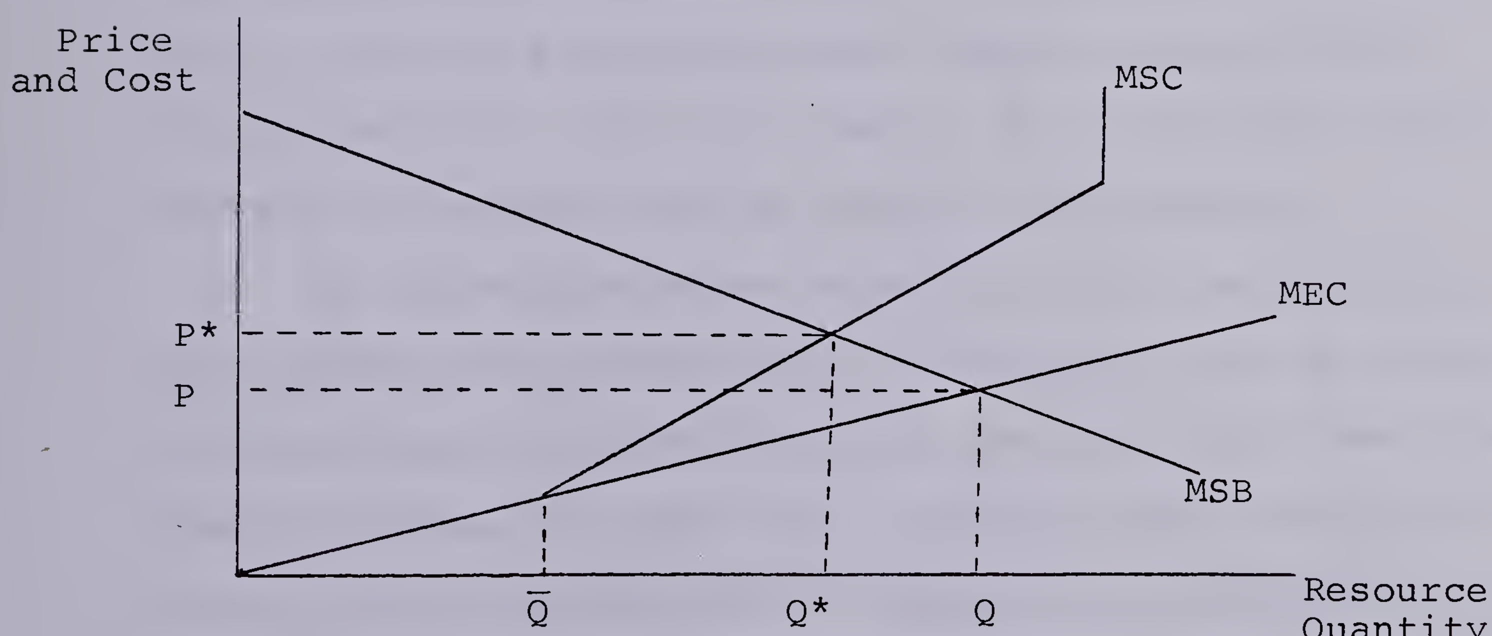
simple graphic example. Assume a fixed stock of resources AB. Consumption is limited to two periods, t (the present) and t + 1 (the future). Under these assumptions consumption can occur either all in period t, all in t + 1, or a portion in each period. With a fixed resource stock, consumption in t will limit consumption in t + 1. The level of consumption in t will depend on the rate of time preference of the group or society in question. If present consumption is valued more highly than future consumption, more will be consumed in period t. The actions of the initial generation constrain the options of generations to follow.

Assuming away transportation and development costs, consumption of an exhaustible resource in any period can be thought to result in two types of cost. First there are

extraction costs. Second, there are costs imposed on future generations by consumption in the present. Scott[1] refers to the second type as user costs. With enough resources to meet future needs, user costs could be ignored. With scarce resources a more realistic situation is one of increasing user cost with increasing present consumption. As user costs are a type of externality or non-market effect, ignoring them will result in over-depletion of resources at the expense of future generations. Figure 3.2 illustrates how consumption diverges from optimality when these external costs are ignored. User costs are assumed to become positive once consumption exceeds $\bar{Q}$.

Figure 3.2

Optimal Resource Utilization



Source: J. McInerney, "The Simple Analytics of Natural Resource Economics," Journal of Agricultural Economics, 1976.

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[1] A.D. Scott, "Notes on User Cost," Economic Journal, Vol. 63, 1953, pp. 368-384.

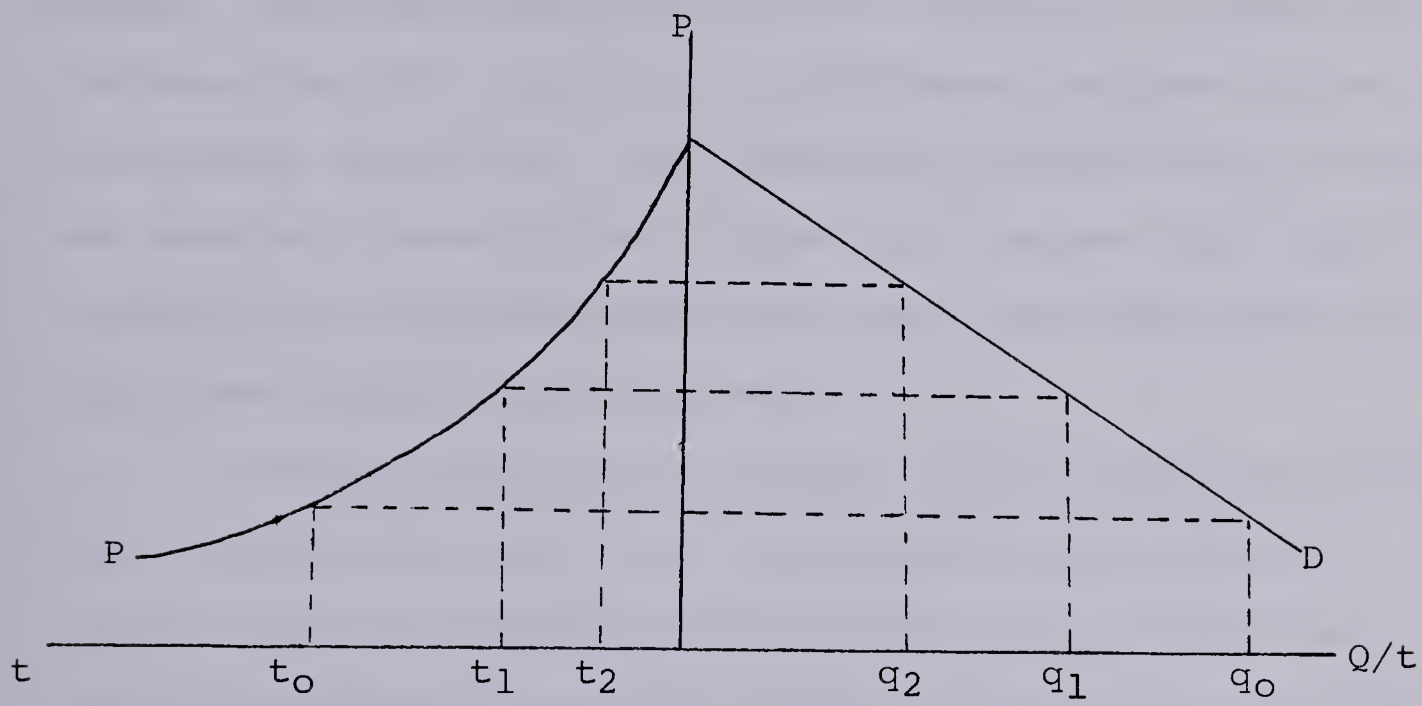
In cases where resource ownership is not clearly defined, the firm considers extraction costs (MEC) alone in the extraction decision. Social costs (MSC) includes extraction costs plus user costs. If left to the market, output will be greater and price less than socially optimal.

The notion of user cost is based on the assumption that the resource in question will be necessary in the future and that substitutes will not come on stream. Thus, resource extraction in the present will result in higher future production costs or will preclude future production altogether. Further, as the number of generations expected to follow the present generations increases, so too should user costs. As the number of future generations approaches infinity, the user cost of present consumption should approach infinity. Allocation of a fixed resource stock over an infinite population would require consumption in each period to be infinitely small. As a conceptual device, the idea of user cost can be helpful nevertheless.

An opposing argument regarding equity among generations assumes that those alive in the future will be better off than those living today in the same way that those alive today are better off than their ancestors were because of greater capital accumulation. Resource scarcity problems will be solved by substitution to new techniques and resources. Levels of resource consumption today may not be important.

In either case an important consideration is the timing of extraction of exhaustible resources. Ideally,

Figure 3.3
Choke-off Price in Resource Use



new resources should come on stream when increasing resource scarcity has raised supply costs so as to severely limit the quantities of 'conventional' resources demanded (see Figure 3.3). If prices rise too quickly, substitutes may appear before conventional resources are used up, making them obsolete (assuming substitutes are superior). Alternatively, if prices do not rise fast enough to reflect increasing scarcity, resource substitution may not begin early enough to allow for lead time in new resource development.

Under conditions of certainty, the profit maximizing firm will try to maximize the present value of net returns from a resource stock. If the price of the resource is rising at a rate less than the rate of interest, the firm should extract more in the present than in the future. The proceeds from sales could then be invested at the going rate of interest, thereby increasing profits. With resource

prices rising more rapidly than the rate of interest, a more conservative approach to resource extraction would be expected. Only when the price and the interest rate move at the same time will the firm be indifferent between future and present extraction. The preceding assumes that the firm has knowledge about future prices and interest rates and has flexibility in its extraction decision, once investments in labour and capital have been made.

Leaving the static framework, an optimal rate of resource utilization over time requires that the marginal social value of natural resource commodities at any time t equals the marginal production cost plus user cost plus the marginal loss of environmental services.[1] Put more simply, output at every time t should equate marginal cost with marginal benefits. These marginal social benefits and costs must consist of both private and external components.

Renewable Resource Economics

To the extent that the Cold Lake oil sands project will be incompatible with renewable resource uses in the region, a brief discussion of the economics of renewable resources seems in order. The theory can assist in the identification and solution of potential resource use conflicts.

Many renewable resource species grow in a manner similar to that represented by Figure 3.4. The

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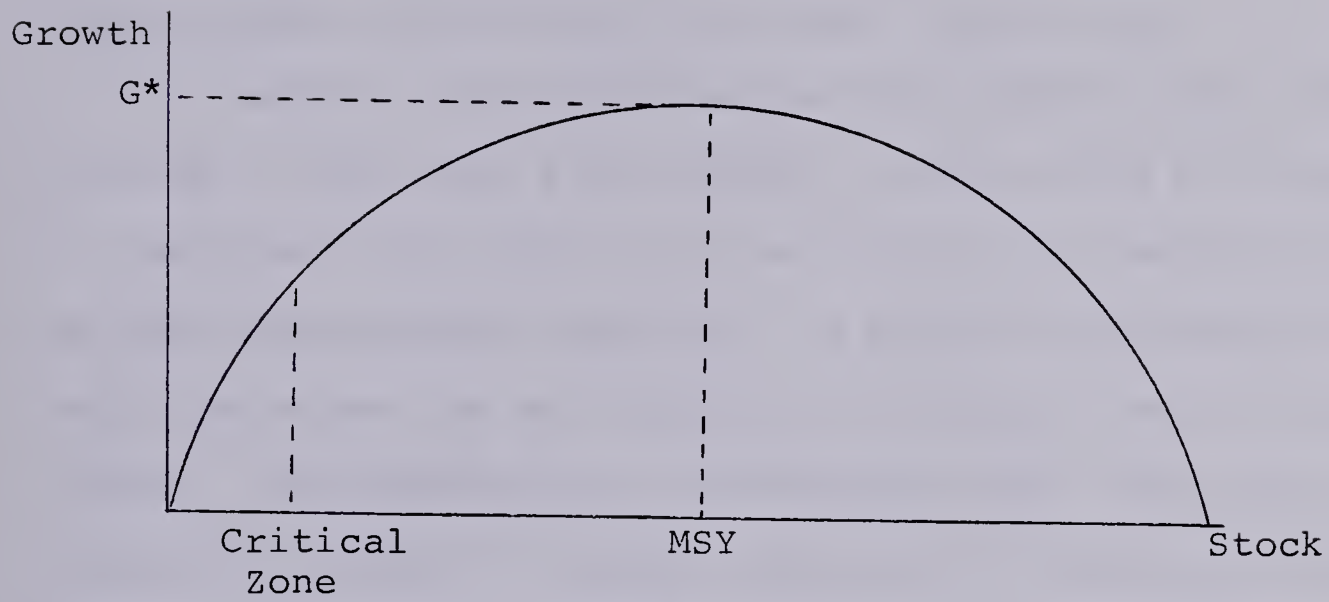
[1]Adapted from C.W. Howe. Natural Resource Economics, (New York: John Wiley and Sons, 1979), pp. 92-93.

Figure 3.4

Growth of a Renewable Resource



vertical axis represents the amount of biomass (fish, wildlife, timber) that can be harvested in perpetuity at various stock sizes. At stock sizes denoted by MSY (maximum sustained yield), an amount G* can be harvested annually. At any point to the right of MSY, the stock size is greater but the growth rate is diminished. Overcompetition for food or space may lead to such a situation of declining growth rates. At points to the left of MSY, the species breeding stock is below optimal resulting in a reduced growth rate. For some wildlife and fish species there may be some threshold stock size, or critical zone, below which the species is unable to reproduce and grow.[1] Depletion of the stock beyond that point will eventually result in extinction of the species. On economic grounds, a species should be allowed to reach

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[1]For a discussion of the critical zone concept see S.V. Ciriacy-Wantrup. Resource Conservation: Economics and Policies. Division of Agricultural Sciences, (Berkeley: University of California, 1968), pp. 256-257.

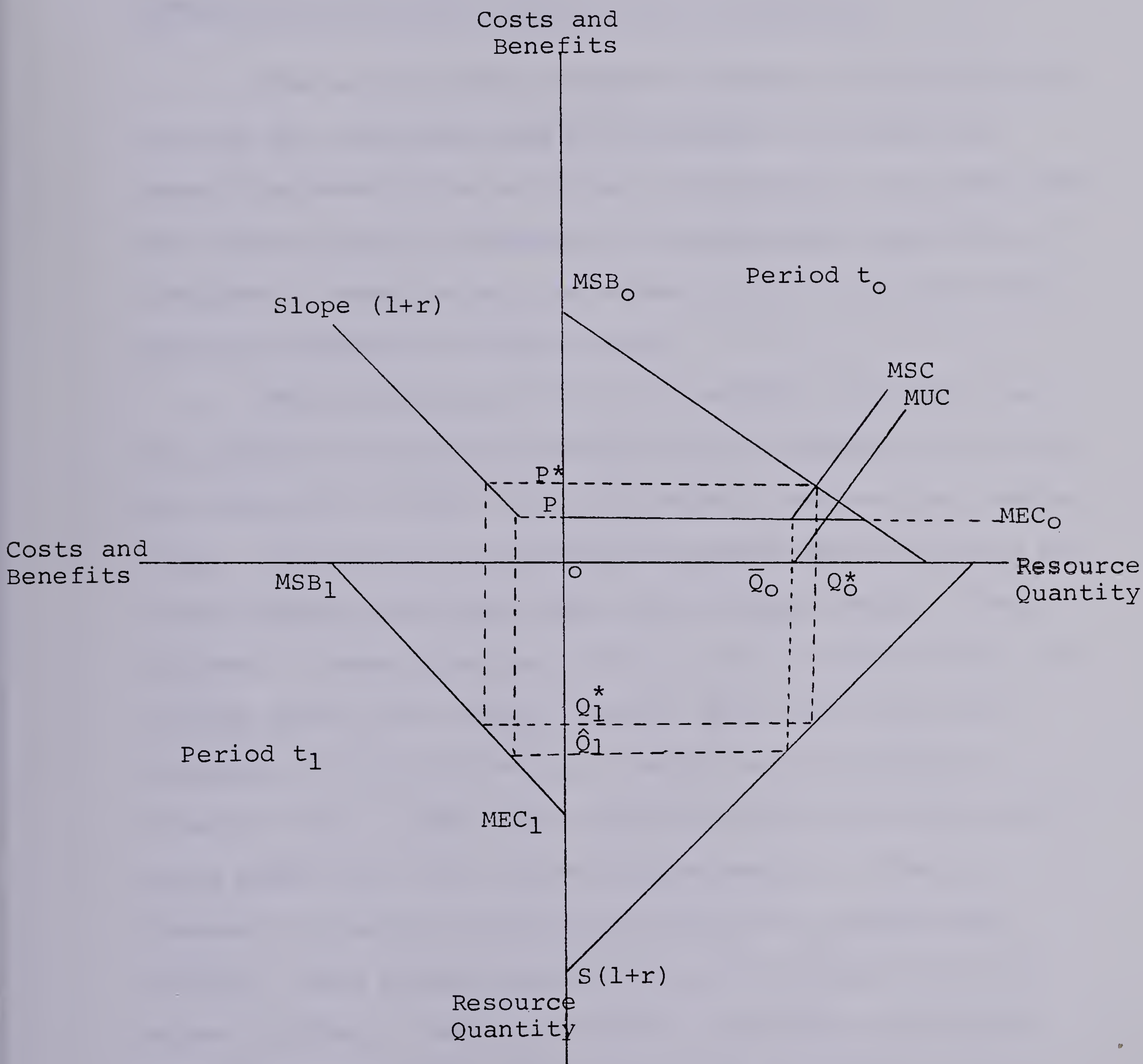
MSY only if the extra returns from waiting exceed or are equal to the extra costs. The biological maximum may differ. from the most economically efficient stock size.

Assume a two-period model with species stock size S growing at some rate g per period. From a size S in period t, the stock will grow to a size S $(1 + g)$ in period $t + 1$. As with nonrenewable resources, an optimal allocation is one which maximizes the net benefits to society from the resource. Net benefits will be maximized when the last unit consumed in period t yields the same net benefit as the last $(1 + g)$ units consumed in $t + 1$. The cost of consuming a unit of the resource today is the benefit that unit would have yielded if left for the future. McInerney offers a graphical representation of an optimal renewable resource allocation over two periods. A reproduction is provided in Figure 3.5. In Figure 3.5, the optimal level of resource use in period t is Q_o^* where $MSB_t = MSC$ at a price P*. User costs become positive once consumption exeeds $\overline{Q}_o$.

Land differs from both exhaustible and renewable resources. Although there is a fixed stock of land, the services it provides can be considered to be infinite. Thus, an acre of land can provide one acre of agricultural activity or one acre of space for petroleum facilities indefinitely assuming adequate management. The intertemporal allocation decision is in choosing what services a particular parcel of land should supply. An optimal allocation of land resources is one where the change in current benefits from transferring land to one use is equal to the

Figure 3.5

Optimal Intertemporal Allocation of
a Renewable Resource



Source: J. McInerney, Journal of Agricultural Economics May 1978.

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[1]J. McInerney, "On the Optimal Policy for Exploiting Renewable Resource Stocks," Journal of Agricultural Economics, May 1978, p. 187.

discounted future benefits foregone from removing that land from a second use.

Benefit-Cost Analysis - Theoretical Foundations

The benefit-cost procedure attempts to identify and measure the advantages and disadvantages to a specified group from undertaking a project or program. In a social BCA all direct costs and benefits are considered, regardless of incidence. Benefits and costs need not be associated with monetary receipts or expenditures.

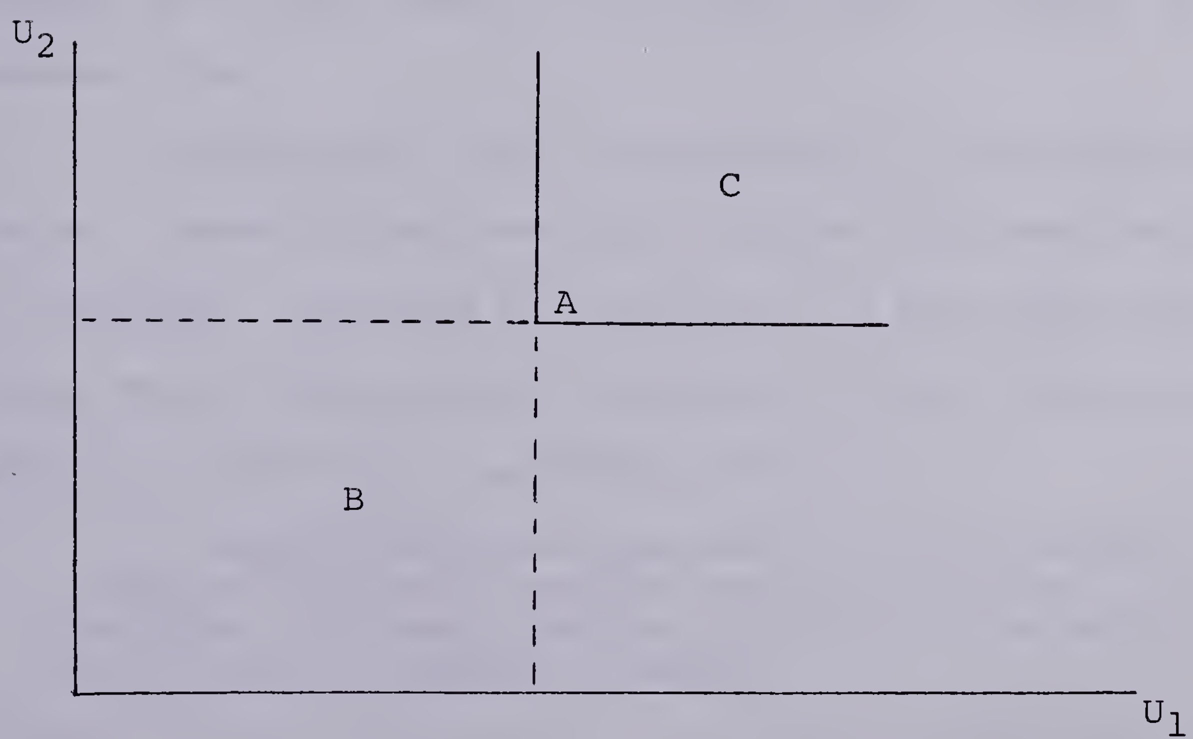
The foundation of BCA is in welfare economics, as the approach attempts to maximize social welfare by allocating resources to their 'most preferred' uses and use combinations. Selecting policies which maximize the difference between benefits and costs moves the economy toward a Pareto optimum. A Pareto optimal state is one in which no one can be made better off without someone being made worse off. According to this criterion a change was in society's interest only if some could be made better off with no one being made worse off (a Pareto improvement). Usually changes in resource use do not produce such unambiguous results. Some persons benefit from the change at the expense of others. As interpersonal comparisons of utility are not possible, the Pareto criterion is unable to deal with situations in which gains and losses arise at the same time. Figure 3.6 represents the problem graphically. Consider a two person economy originally at some point A.

A change moving the economy into region C is a Pareto improvement (Pareto superior to A). A change which moves the economy into region B is Pareto inferior. The northwest and southeast quadrants are indeterminant with one person being made better off at the expense of the other.

The welfare improvement principle became more workable with the introduction of compensation by Kaldor and Hicks. Under their refinement a change could be said to be a potential welfare improvement if the gainers from a change could compensate the losers and still remain better off. Compensation need not be made, the requirement is only that it could be made through costless transfers.

Figure 3.6

Pareto Criterion in a Two-Person Economy



BCA proceeds on the premise that individual preferences are important. In a market economy preferences are expressed by willingness to pay the established price. Multiplying the quantity sold by the market price (total revenue) is not considered to be an accurate estimation of consumers' preferences. Some persons would be willing to pay a price for a given commodity above that determined by the forces of supply and demand. Total willingness to pay, therefore, can be considered to be the sum of what consumers must pay plus what some would have been willing to pay (consumers' surplus). The benefit from a change in resource use can be approximated by the change in total willingness to pay. Costs of the change can be considered to be the benefits foregone from not undertaking the next best alternative. In Figure 3.7, the shaded region can be thought of as the benefits generated from a change in resource use.

In practice, BCA is concerned with economic efficiency. Benefits and costs are treated the same regardless of incidence. Nothing in the theory of BCA would disallow a change which improved the well-being of the rich at the expense of the poor. As Mishan states:

> . . . the quantitative outcome of a cost-benefit calculation itself carries no distributional weights, it shows that the total of gains exceeds the total of losses, no more.[1]

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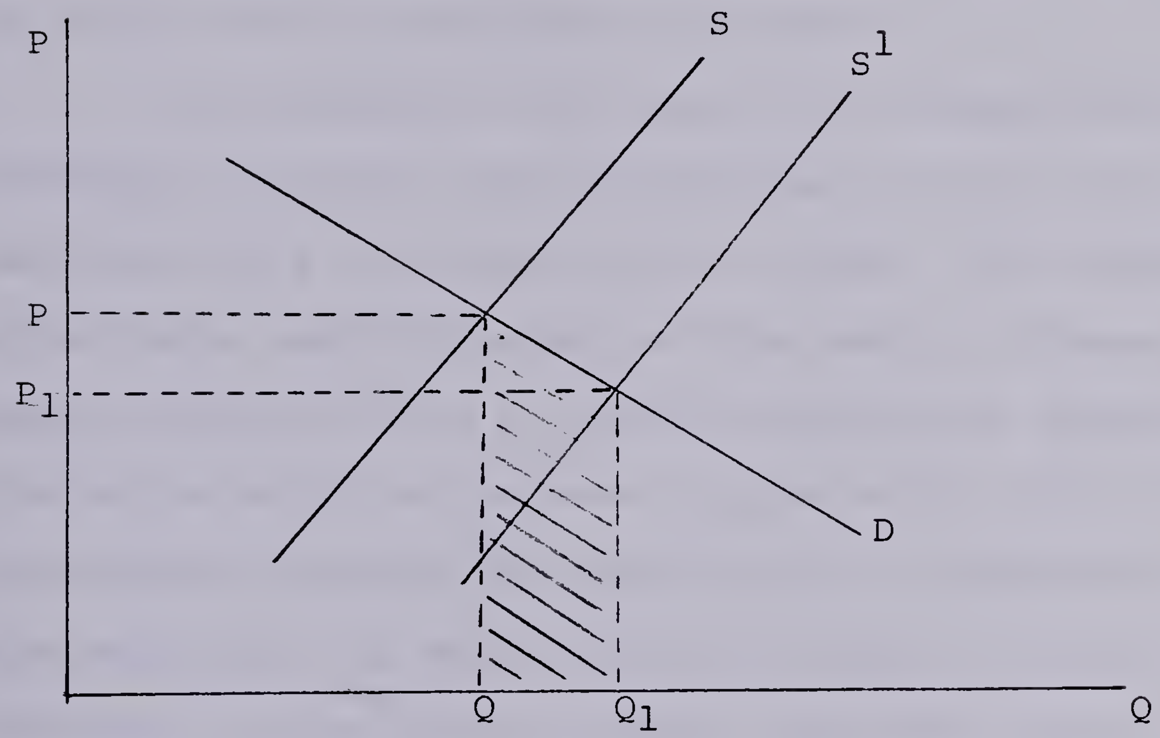
[1]E.J. Mishan, Elements of Cost-Benefit Analysis, (London: George Allen and Unwin Ltd., 1972), p. 15.

Figure 3.7

Benefits from a Resource Use Change



Where distribution is considered important, the expected gains and losses can be weighted. Usually distributional effects are ignored, presumably because most projects are thought to have insignificant redistributional consequences. A second argument for ignoring distributional effects is that persons are paid according to their marginal product, and, in some sense, deserve the incomes they receive. If society considered the present distribution of wealth inappropriate, a change would more effectively be made through direct policies. These arguments are not unanimously accepted.[1] Taking distribution explicitly into account in a BCA will require a weighting scheme that is

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[1] See, for example, A.K. Dasgupta and D.W. Pearce. Cost-Benefit Analysis: Theory and Practice, (The MacMillan Press Ltd., 1972), pp. 62-64.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

somewhat arbitrary. For that reason the usual practice is for the analyst to indicate the direction and possible magnitude of the expected distributional change and leave the final choice to the decision maker.

The mechanics of BCA calls for a comparison of advantages (benefits) and disadvantages (costs) to a specified group at a particular point in time. Where benefits and/or costs cannot be measured from market information, the analyst may use direct or indirect methods to generate information which can be used as proxies for them. Where extra-market benefits and costs cannot be measured in any reasonable way, the safe minimum standard, critical value, dominance, or sensitivity analysis approaches may be employed.[1] The existence of intangibles makes a value judgement necessary. Again, it may be preferable for the analyst to limit his analysis to qualitative statements if an attempt at quantification could reduce the objectivity of the study.

Benefits and Costs of the Cold Lake Oil Sands Project

The primary benefit of the Cold Lake development is the value of the output produced. The value of the upgraded crude is perhaps best estimated by the market price. The market value of inputs used provides a useful first

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[1]A good discussion of these approaches can be found in D. De Pape and W. Phillips, "Approaches to Incorporation of Intangibles into Natural Resource Utilization Evaluation" Unpublished paper, University of Alberta, 1980.

approximation of the social costs of the project. These costs include such things as the costs associated with project operation.

In the study undertaken for the developer three economic scenarios were presented: a minimum net social benefit (NSB) case; a maximum NSB case; and a middle case. The minimum case assumed that the total developer cash flow was a leakage from Canada. In the maximum case, the entire gross impact is viewed as a net social benefit under the assumption that all resources would otherwise be unemployed. The middle case included net developer cash flow with adjustments for infrastructure costs, interprovincial pipeline and infrastructure economics of scale, as well as some unemployment reduction benefits. Other benefits to Canada and Alberta include: a positive impact on the country's balance of payments, security of oil supply, upgraded workers' skills, balanced economic growth across Alberta, research and development benefits, increased access to recreation areas, and beneficial impacts on the native people of Alberta. Some of these benefits such as upgraded workers' skills and research and development effects may require additional costs to be achieved.

Additional social costs cited in the study done for Imperial Oil include environmental damage, social problems, and aggregate demand pressures in the Albertan economy.

Foster Research found the Cold Lake oil sands project to generate positive net benefits to both Alberta

and Canada at a five and ten percent real rate of discount under their 'middle case' scenario. Table 3.1 presents these results for the benefits of the project to Canada.

The present chapter has dealt with some of the conceptual considerations and problems in selecting an optimal resource use mix. The chapter then introduced the more practical BCA framework which is commonly used in choosing among resource use options. BCA will be central to the analysis to follow in Chapter IV.

Table 3.1

'Middle Case' NSB

PV 1978 ($ x 10^6)

	Coal Fuel		
	@ 5%	@ 10%	@ 15%
First Approximation to Net Social Benefit	1717	(64)	(615)
Less Infrastructure Costs	50	28	17
Plus Interprovincial Pipeline Economies of Scale	49	25	14
Plus Infrastructure Economies of Scale	13	9	6
Plus Unemployment Reduction	107	85	68
Middle Case NSB	1836	27	(544)

Source: Foster Research. Cost-Benefit Analysis of the Cold Lake Oil Sands Project, 1978.

CHAPTER IV

ANALYSIS

In the present chapter the benefit-cost framework is employed to present economic analyses of the Cold Lake oil sands project under a number of different assumptions. In addition, anticipated effects of the development on the other resource uses in the region will be discussed.

Before proceeding with the analysis, the assumptions used in the study are introduced and justified. The introduction of some different assumptions should add breadth to the study undertaken for the developer. As social and private optima may diverge, one might argue that the government involved should perform its own benefit-cost analysis. The analysis undertaken for Imperial Oil may reflect their interests to a greater extent than would a publicly sponsored analysis. The present study will, hopefully, offer a more objective look at the Cold Lake development based on more recent information.

Choice of Discount Rate

The selection of discount rate is a major determinant of the outcome of a benefit-cost study. High rates favour projects with returns which begin immediately after project completion. Lower rates favour projects with

longer payback periods.

Two schools of thought exist on how the discount rate should be determined. Some argue that the discount rate should reflect the opportunity cost of capital in the private sector. The second school takes the position that the discount rate should be determined by society's time preference for current as opposed to future consumption. The discount rate as determined by the social rate of time preference need not be related to any rates of interest or return found in the economy.

The opportunity cost approach emphasizes economic efficiency over time in resource allocation. Thus, resources should be removed from the private sector and allocated to the public sector only if returns generated are comparable or greater than returns from private investment. To do otherwise would reduce the welfare of society. One major problem with this approach is in selecting the appropriate opportunity cost, as returns vary among industries.

The social time preference school argue that capital markets are imperfect and therefore the discount rate need not be as high as market rates. Other reasons why the social discount rate need not be as great as market rates include: (a) future generations are not represented in current decisions; (b) consumers are myopic and make intertemporal decisions in ignorance; and (c) returns in the private sector have a risk component which may not be

relevant to public investments.

The discount rate controversy has yet to be solved. Rates chosen can vary with the riskiness of the project, the magnitude of private versus public expenditure anticipated, and the economic philosophy of the analyst. As the outcome of a benefit-cost analysis (BCA) may be dependent on the discount rate chosen, care should be taken in its selection.

Real rates of discount should be distinguished from nominal or money rates. Real discount rates are deflated to remove the effects of inflation. Expenditure and revenue streams can thereby be considered in 'constant dollars'.

The base discount rate selected by Foster Research appears to favor the opportunity cost of capital argument. They employed a 10 percent base rate with sensitivity analysis using five and 15 percent in real terms. In support of their choice, the Canadian Treasury Board's Benefit-Cost Analysis Guide and a study by Glenn Jenkins,[1] which concluded that the real weighted average rate of return for manufacturing and non-manufacturing industries in Canada over the period 1965 to 1969 was 9.6 percent, were cited.

For the present study a range of real discount rates from four to nine percent inclusive is used. A nine percent discount rate approximates Jenkins' findings for rates of return in the private sector. Rates in the four to seven percent range are representative of real rates of return on

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[1] Glenn P. Jenkins, "The Measurement of Rates of Return and Taxation from Private Capital in Canada," Benefit-Cost and Policy Analysis, (Chicago: Aldine Publishing Company, 1972), p. 225.

long-term government bonds (see Appendix C - Table C.1). Further support for discount rates in the range selected can be found in a study undertaken to examine water supply alternatives in the Oldman River basin in which a real rate of five percent was selected as a basic discount rate. Sensitivity to results were tested using three and ten percent in that study.[1] Howe concluded that 6 3/8 percent was as appropriate as any other choice of discount rates.[2]

Oil Price Levels

Selecting an appropriate price per barrel for upgraded crude is difficult because, at this time, no agreement has been reached between the developer and the provincial and federal governments. In the study undertaken for the developer, a then world price of $14.50 ($1977) for upgraded crude was used. Since then, oil prices have soared. In 1980, world prices for crude range from $28.00 per barrel for Saudi Arabian light to over $37.00 for Nigerian and Algerian crudes. Canadian crude prices are approximately half the current world price at $16.75 per barrel (excluding the newly introduced Petroleum Compensation Charge). Because of the wide divergence in prices, the present study will use a variety of possible prices to illustrate how the economic viability of the project changes

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[1] Marv Anderson and Associates Limited, "Oldman River Basin Study, Phase II," Economic Analysis of Water Supply Alternatives, (April 1978), pp. 93-95.

[2] C.W. Howe, Natural Resource Economics: Issues, Analysis and Policy, (New York: John Wiley and Sons, 1979), p. 158.

as world prices are approached. Regardless of the price actually received by the project, on economic efficiency grounds the correct price to use is the world price. The world price reflects the opportunity cost if oil is bought or sold in markets other than the subsidized Canadian domestic market.[1]

Developers of the Cold Lake project can be expected to receive a price for its output which at least approaches the world price. There are two reasons to support this expectation. First, the Syncrude project received the world price (until recently) for oil extracted from the tar sands near Ft. McMurray. Second, the policies of both the Alberta and Federal governments have been to encourage development of the oil sands as a means of achieving energy self-sufficiency.[2]

Crude oil prices have increased considerably since 1971. Over the period 1971 to 1979 the price of Saudi light rose from $4.41 per barrel to over $21.00 in 1979 dollars (see Appendix C - Figure C.1). The geometric mean of this series indicates an annual price increase of 21 percent. Whether world oil price movements over the next decade will be as active as during the 1970's is uncertain. The rapid price increase of the past may have been an attempt by the

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[1] An interesting discussion of Canadian energy pricing policy both before and after the October 1980 Federal Budget can be found in B.L. Scarfe, "The Federal Budget and Energy Program, October 28th, 1980: A Review," Unpublished paper, Department of Economics, University of Alberta, 1980.

[2] See Alberta Hansard, June 5, 1979, p. 184 and National Energy Board. Canadian Oil Supply and Requirements, September 1978, p. 62.

OPEC nations to recoup revenues lost when the international oil companies controlled petroleum supply.

For the purposes of the present study, the assumption is made that the large price increases of the past will not continue. Instead, small real price increases are assumed (i.e. increase in relative prices). In part, this assumption is an attempt to present conservative estimates. The assumption conforms to the goals of OPEC's Ministerial Committee on Strategies. The Committee reportedly ". . . favours the indexing of oil prices to take account of dollar depreciation and inflation in the industrialized countries and, for the longer term, regular increases in the real price to bring it up to equality with the cost of other forms of energy--reckoned to be $30 to $50 a barrel."[1] Price increases which are greater than those assumed here will mean that the results presented here are biased downward.

Five possible yearly price increase scenarios are presented. Project cost increases are ignored. As both prices and costs may move together, the price increases can be considered to be net of cost increases. For example, a certain real price increase could be thought of as the difference between a real price increase and some associated, but smaller, increase in project costs. As none of the three most popular decision rules is ideal, the study will present benefit-cost ratios, net benefit estimates, and

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[1] Petroleum Economist, Volume XLVII, Number 2, February 1980, p. 47.

internal rates of return.

Since the initial proposal, cost estimates for the Cold Lake project have risen from $4.7 billion ($1977) to approximately $8.2 billion ($1979) today. This increase amounts to a 50 percent increase in real terms (assuming a 10 percent inflation factor per year). Oil prices over the same three year period have increased almost 100 percent--from $14.50 (1977 dollars) to $33.00 (1979 dollars).

Analysis

Using the developer's estimates of capital and operating expenditures as a measure of project costs, and expected revenues from sales of upgraded crude as a proxy for benefits provides a first approximation of the economic feasibility of the project. Other benefits and costs are ignored initially. Capital costs will occur during the six year construction phase with the building of production and upgrading facilities, roads, pipelines, and the like. Capital costs over the remainder of the project life arise predominantly from the drilling of new wells. Operating costs include such items as labour, power, coal and natural gas, and materials. A breakdown of the anticipated cost and revenue streams is provided in Appendix C, Table C.2.

The economic viability of the project will be examined using three price scenarios: $16.00 per barrel of upgraded crude; $25.00 per barrel; and $34.00 per barrel. Discount rates will be five, seven, and nine percent. A

price of $16.00 ($1979) approximates the present Canadian domestic price. Thirty-four dollars ($34.00) per barrel slightly exceeds the current price of some high-priced foreign crudes. As project costs have risen since the time of application, a middle case price of $25.00 is also presented. The middle case can be thought of as the world price net of cost increases. For simplicity, a zero price increase scenario is used. Readers interested in the various relative price increase scenarios at the whole range of discount rates can refer to Appendix C, Tables C.3.1 to C.3.15.

These preliminary results are presented in Table 4.1. At $16.00 per barrel of upgraded crude, the project appears reasonably attractive from a private perspective. A real internal rate of return of 11 percent is not low although the riskiness of an untried recovery technique may warrant some premium for risk taking.[1] At prices of $25.00 and $34.00 per barrel, the project looks highly profitable even including some risk premium.

The developer has indicated that the project would have some positive effects on unemployment in Alberta and that without the Cold Lake development millwrights, carpenters, ironworkers, and pressure welders would be in surplus in the province in a few years. As these four trades account for approximately 21 percent of the total construction employment of 21,370 man-years, the unemployment

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[1]One could argue that a company as large as Imperial Oil could effectively pool its risks and may not require a large risk premium.

Table 4.1

Economic Evaluation of the Cold Lake Oil Sands Project Using Selected Price and Discount Rates ($1979)

Price/Barrel	i	5%	7%	9%
	NB*	$2910	$1520	$ 610
16.00	B/C	1.42	1.27	1.13
	IRR	11.06%	11.06%	11.06%
	NB*	$8472	$5595	$3659
25.00	B/C	2.22	1.98	1.76
	IRR	18.91%	18.91%	18.91%
	NB*	$14025	$9664	$6703
34.00	B/C	3.01	2.69	2.40
	IRR	24.78%	24.78%	24.78%

* Net Benefits are in $ x 10^6.

benefits of the development were determined to be $137 million (5,500 man-years times $25,000 per worker).[1] These benefits would amount to $138 million, $130 million, and $122 million ($1979) discounted at five, seven, and nine percent respectively. At $16.00 per barrel these unemployment benefits are relatively important, increasing social net benefits by between four and 20 percent. As oil prices approach the world prices, the significance of this benefit to the analysis declines.

One may question the inclusion of these unemployment benefits in the analysis. While the assumption about surplus tradesmen may have been relevant at the time the study was undertaken for the developer, one could argue that the proposed Alaska highway pipeline and Alsands project, if undertaken, will absorb most, if not all of any surplus tradesmen. Employment benefits from the Cold Lake oil sands project may be small or non-existent.

Publicly provided information is expected to be substantial and should be included in an economic analysis. The project will require upgrading and/or expansion of education, health, police and fire protection, transportation, recreation, and other services. At discount rates of five and 10 percent, estimated infrastructure costs for the project were determined to be $50 million and $28 million respectively. Considering the magnitude of the development, these figures appear low. The developer's study defends the

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[1]See Foster Research, p. IV-29.

estimates by arguing that municipal and provincial tax payments by employees will offset much of the additional infrastructure cost. Their argument has some merit. Nevertheless, if infrastructure is upgraded to accommodate the construction phase employees and their families, that assumption will only be reasonable if the employees pay their share of infrastructure costs during the five years that are spent working in these communities or if the construction phase workers take up permanent residence in the area. One may doubt whether either of these situations will arise. Likely, the construction phase employees will be transient, leaving much of the tax burden on operating phase employees living in the area, permanent long-time residents, and the general public.

Adequately dealing with infrastructure costs for the Cold Lake project is difficult at present. Although estimates of infrastructure needs and costs have been prepared by the Cold Lake Regional Coordinating Committee, the report has not yet been made available to the public. From the information that is available, additional problems arise. First, natural growth in the region will require some additions to existing facilities which should not be attributed to the project. Second, apportioning costs among users is not always straightforward.

The Department of Hospitals and Medical Care plans two new hospitals for the Cold Lake region contingent on project approval. One hospital, at Bonnyville, will provide

95 acute beds as well as 30 auxilliary beds. Cost estimates for the facility are $13.7 million. The second hospital, planned for the community of Cold Lake, will have 100 acute patient beds, 30 nursing, and 20 auxilliary beds at an estimated cost of $14.7 million. Charging the total cost of both of these facilities to the Cold Lake project would be inaccurate as some expansion of the facilities at Bonnyville are scheduled to occur regardless of the fate of the oil sands project.[1]

Over the next eight years Alberta Transportation plans to spend $40.7 million in the Cold Lake region. A $5.6 million upgrading of secondary highway 992 from Ardmore to highway 55 is currently underway.[2] A large portion of the total expenditure could rightly be attributed to the Cold Lake development. To suggest that the entire sum should be charged against the project may be inappropriate. Some of these improvements may also benefit other users such as the proposed Alsands heavy oil development (if undertaken) and as such should bear a portion of the costs.

To see how sensitive the results are to changes in infrastructure costs the developer's estimates are taken to be the middle case scenario. As upper and lower bounds, infrastructure costs which are one-half and double the

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[1]Telephone conversation with Terry Roberts, executive assistant to Hon. D.J. Russell, Minister of Hospitals and Medical Care, August 12, 1980.

[2]Conversation with Jim Lovett, Alberta Transportation, August 13, 1980.

developer's estimates are used. Due to computational problems in arriving at the developer's estimates, the infrastructure scenarios for seven and nine percent are only estimates. Nevertheless, the purpose of a sensitivity analysis is not, necessarily, to get an accurate dollar figure but rather to see how the total economic viability of the project is affected when components of the analysis are altered. Tables 4.2a, b, and c illustrate how changes in infrastructure costs affect the economic efficiency of the development.

Again, as in the case of unemployment benefits, infrastructure costs lose much of their importance to the analysis as world prices are approached.

Other expected tangible benefits of the project include Interprovincial Pipeline economies of scale, reckoned to amount to $49 million ($1977) at a five percent discount rate, and infrastructure economies of scale, amounting to $13 million ($1977) at a five percent discount rate.

To put the magnitude of the net benefits in some perspective, the population of the region (20,118 in 1976) would have to be willing to pay approximately $142,000 per person at a five percent discount rate and an oil price of $16.00 per barrel to have the project stopped.[1] The above assumes that no good alternative sources of supply exist. With oil prices which approach the present world price, the

[1]Determined by dividing the middle case net benefit scenario from Table 4.2a by the 1976 population.

Table 4.2a

Impact of Infrastructure Costs on the Economic Viability of the Cold Lake Oil Sands Project ($1979)

i / Price/Barrel		5%	7%	9%
		(1979 dollars x 10)		
	First approximation to SNB	2,910	1,520	610
	<u>Low Cost Scenario</u>			
	Infrastructure Costs	25	20	15
	Net Benefits	2,885	1,500	595
16.00	<u>High Cost Scenario</u>			
	Infrastructure Costs	100	80	60
	Net Benefits	2,810	1,440	550
	<u>Middle Case</u>			
	Infrastructure Costs	50	40	30
	Net Benefits	2,860	1,480	580

Table 4.2b

Impact of Infrastructure Costs on the Economic Viability of the Cold Lake Oil Sands Project ($1979)

Price/Barrel \ i		5%	7%	9%
		(1979 dollars x 10^6)		
	First approximation to SNB	8,472	5,595	3,659
	Low Cost Scenario			
	Infrastructure Costs	25	20	15
	Net Benefits	8,447	5,575	3,644
25.00	High Cost Scenario			
	Infrastructure Costs	100	80	60
	Net Benefits	8,372	5,515	3,599
	Middle Case			
	Infrastructure Costs	50	40	30
	Net Benefits	8,422	5,555	3,629

Table 4.2c

Impact of Infrastructure Costs on the Economic Viability of the Cold Lake Oil Sands Project ($1979)

Price/Barrel \ i		5%	7%	9%
		(1979 dollars x 10^6)		
	First approximation to SNB	14,025	9,664	6,703
	<u>Low Cost Scenario</u>			
	Infrastructure Costs	25	20	15
	Net Benefits	14,000	9,644	6,688
34.00	<u>High Cost Scenario</u>			
	Infrastructure Costs	100	80	60
	Net Benefits	13,925	9,584	6,643
	<u>Middle Case</u>			
	Infrastructure Costs	50	40	30
	Net Benefits	13,975	9,624	6,673

figure gets much larger. If one employed a critical value type of approach in the decision-making process, the intangible negative impacts of the development on the region would obviously have to be great in order for the project not to proceed.

As a second example, assume that agriculture in the immediate vicinity of the plant is lost forever due to project development. Further, assume total value of agricultural production to be an appropriate measure of benefits from the agricultural industry (i.e. exclude costs of production). As approximately 75 percent of the census farms in C.D. 12 were located in Counties 13, 19 and Municipal District (M.D.) 87 in 1976, the assumption is made that these three subdivisions also account for 75 percent of production in C.D. 12. The 75 percent figure is likely an understatement. A $62.4 million annual loss of agricultural production (75 percent of C.D. 12 production of $83.2 million in 1976) discounted at five percent amounts to a total loss of $1,248 million in perpetuity. At $16.00 per barrel the lost production does not change the economic viability of the project, although the net benefits are lowered considerably. At an oil price which approaches the world price, the loss of agricultural production has only a negligible effect on the economic viability of the project.

Agriculture

As agriculture is the most important resource use in the development region at present, a discussion of potential impacts of the project is warranted. In general, the agricultural community appears in favour of the proposed development.[1] Nevertheless, there is some apprehension.

Although none of the land to be directly disturbed by the Cold Lake oil sands project is presently being used for agricultural purposes, the roads and pipelines necessary for the development will cross agricultural land. The problems these right-of-way and expropriations create are largely in the form of inconvenience, particularly if parcels of land become divided in such a way that large machinery can no longer manoever. To affected farmers this inconvenience could translate into higher costs of production and reduced revenues. Rights-of-way leases and payments for damages should eliminate most conflicts.

Land speculation is another area of concern to producers. High land prices could make expansion of existing farms uneconomic and discourage new entrants into the industry. At the same time, owners of farm land near the communities of Cold Lake, Bonnyville, and Grand Centre could make large gains from land sales to developers. While the industry as a whole may suffer from rising land prices,

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[1] Lakeland Environmental and Agricultural Protection Society (L.E.A.P.S.) and Northeast Branch of the Alberta Institute of Agrologists, "A Summary of Agricultural Land Use Concerns Regarding the Proposed Imperial Oil Ltd. Cold Lake Heavy Oil Project."

individual farmers may find their economic position improved. Likely much of the speculative activity has already occurred and may be an impact beyond the control of government policy at this time.

The developer has suggested that the project may provide farmers with a source of off-farm employment to supplement farm incomes. Employment opportunities will arise only if farmers possess the necessary skills. Producers fear that the high wages offered in the oil industry will make finding (and keeping) part-time farm labour more difficult and expensive.[1] A potentially positive impact of the oil sands development is the creation of a large market for locally grown produce. Alberta Municipal Affairs has identified market gardening and greenhouse operations as possible areas for diversifiction.[2] Whether or not such market opportunities materialize will depend, in part, upon the initiative of local farmers and the extent of the market potential. If local producers must compete with the large food retailers, benefits from an increased local market may not arise.

For a development of the scale of the Cold Lake oil sands project, the total land area directly involved is relatively small. Over the twenty-five year life of the

[1]There is some evidence to suggest that competition for labour is perceived by producers to be a problem throughout the province. See L.M. Arthur, "The Hired Farm Labour Market in Alberta," Unpublished manuscript, Department of Rural Economy, University of Alberta, December 1980.

[2]Alberta Municipal Affairs, Cold Lake Regional Plan - Agricultural Development, February 1978, p. 19.

development, approximately 2,300 hectares (5,681 acres) will be disturbed. Imperial Oil has stated that the total area will be reclaimed after use. Table 4.3 provides a breakdown of the timing of land use and the estimated area involved.

The greatest concern may be the long-term effects of sulphur emissions on agricultural productivity. The developer admits to the possibility of some minor damage within five kilometres of the plant site. Outside the five kilometre radius, damage is expected to be negligible.

> No perceptible effects of sulphur gas emissions on native species are expected at distances greater than five kilometres from the emission sources.
>
> Agronomic species are generally no more sensitive to sulphur gas than are native species. Since agricultural areas are concentrated in areas more than five kilometres from the proposed plant site, no perceptible effects on agricultural crops are anticipated, either in terms of a visible injury or growth rate reductions.[1]

Assuming the developer is correct in its analysis of sulphur emissions does not mean that the issue can be dropped. Some thought must be given to the possibility that by the end of the century the region will have to contend with five, or perhaps 10 more 'Cold Lakes'. Such a possibility is not unlikely given the political climate in Canada concerning energy self-sufficiency.

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[1]Esso Resources Canada Limited, Final Environmental Impact Assessment, Vol. II, Biophysical Resources Impact Assessment, 1979, p. 28.

Table 4.3

Direct Land Use Within the Cold Lake Project Commercial Development Area*

Initial Requirements	Area (ha.)
Plant 1	220
Plant 2	32
Construction Camps	42
Cooling Pond	14
Coke/Ash Storage	53
Initial Roads, Satellites	122

* Total Commercial Development Area = 14,300 ha.

Approximate Land Use by Year	Area in Use		Area Abandoned and Reclaimed		Total Area Disturbed	
	ha	%	ha	%	ha	%
1986 (startup)	493	3.4	--	--	493	3.4
1993	980	6.8	126	1.0	1129	7.9
2000	1013	7.1	772	5.4	1812	12.7
2007	812	5.7	1446	10.1	2285	15.9
2010 (completion)	--	--	2285	15.9	2285	15.9

Source: Esso Resources Canada Limited, Final Environmental Impact Assessment, Vol. I, Project Description.

Trapping, Fishing, and Recreation

Some disruption of trapping activity can be expected due to the oil sands development. Access roads, noise, and increased traffic levels may disrupt habitat and induce some species to leave the area. A few trappers have portions of their traplines in the development area (see Table 4.4) and will have to relocate elsewhere or reduce the size of line trapped. The magnitude of the losses would, at best, be a guess at this stage.

Two potentially negative impacts of the development on aquatic life and commercial fishing are worth noting. The disposal of effluent into the Beaver River from the project is not expected to seriously affect water quality. To the extent that water quality is affected adversely, costs to society are incurred. A second concern is the possibility of acid rain caused by sulphur emissions during the operations phase. The issue is a relatively new one. The long-term well-being of commercial fishing and water related recreational activities in the area may depend upon the magnitude of the problem. More positively, the development may attract fishermen as a source of employment thereby raising incomes of those remaining in the industry.

The influx of workers into the region that will be associated with the project go-ahead should increase the demand for recreation facilities and services. Local businesses providing services to recreationists would be the primary beneficiaries. The costs of increased recreational

Table 4.4

Registered Traplines on the Imperial Lease

Trapline Number	Total Area of Line*	Area of Line in Lease*	Area of Line (Percent of Line) in Development Area*
54	54.50	43.25	8.50 (32.7)
159	1.33	1.33	3.75 (18.3)
1473	19.50	8.67	6.75 (17.4)
1614	26.00	13.00	17.79 (44.3)
1732	20.50	20.13	
1791	38.83	32.83	21.00 (58.1)
1837	40.17	40.17	4.75 (37.5)
2171	17.00	15.50	
2381	36.17	30.75	
2390	12.67	12.67	
2405	16.67	4.25	
2568	32.00	22.00	

* In $mi.^2$: Total Area of Lease - 271.6 $mi.^2$
Total Area of Development Area - 62.5 $mi.^2$
Total Area of Traplines - 315.3 $mi.^2$
Area of Traplines in Lease - 244.5 $mi.^2$

Source: Resources Management Consultants, Draft Final Environmental Impact Assessment, Vol. II, Socio-Economic Impact Assessment.

demand will be related to the level of publicly provided facilities (parks, campgrounds, etc.) and the level of use. Overuse of facilities and resources may reduce the value of the recreational experience.

In summary, the project appears viable from both a private and a social perspective. Tradeoffs among resource uses and over-time may be required. Spillover effects are real costs (or benefits) of the project and should be considered in an economic analysis. Irreversible negative impacts are of particular concern as alternatives are foregone forever. As long as the sum of the tangible net benefits plus the intangibles arising from the development exceed the social net benefits (or critical value) associated with the present resource use pattern, there can be no economic reason to reject the Imperial Oil proposal. There may be benefits to society from delaying construction however.

The study has examined the proposed development from a national, or global stance. If examined from a regional stance the economic viability may be altered somewhat. For example, if most of the benefits of the project accrue to persons living outside the region while the costs fall entirely on those within the region, then, from a regional stance, the proposed project would not appear as attractive. These linkage and leakage effects are important if regional development is a major consideration.

CHAPTER V

SUMMARY AND POLICY IMPLICATIONS

Summary and Conclusions

The present study has attempted an economic analysis of the Cold Lake oil sands project from a public perspective. The proposed development, to be located near the community of Cold Lake in east-central Alberta, is expected to add approximately 140,000 barrels of upgraded crude per day to overall Canadian oil production. The project is somewhat unique in that it will extract the oil *in situ* by means of high pressure steam injection. Although originally scheduled to begin construction in 1980, delays resulting from a lack of a mutually acceptable pricing agreement among the federal and provincial governments and the developer have pushed the likely starting date ahead to 1981. The quick response of the federal government to the Imperial Oil request for a $40 million loan suggests that the development will proceed at some time--the question is when.

The regional economy has traditionally been agricultural, accounting for 24 percent of total C.D. 12 employment in 1971. Other resource uses such as commercial fishing and trapping are of minor economic importance to the regional economy. These activities appear to provide no more

than supplemental income and part-time employment opportunities for most participants. Due to the magnitude of the proposed development, project go-ahead will alter the relative importance of the existing resource uses to the regional economy.

Results of the analysis indicate that when viewed in isolation, the Cold Lake oil sands project is economically viable from both a private and a social perspective. At a price for upgraded crude of $16.00 per barrel and a seven percent rate of discount, net benefits of the development were determined to be $1,480 million ($1979). Should the project receive $34.00 per barrel for its output, estimated net benefits rise sharply to $9,624 million ($1979). At $25.00 per barrel, which by assumption takes into account both price and cost increases, net benefits were found to be $5,555 million ($1979).

Policy Implications

While the Cold Lake oil sands project does appear economically viable, there may be benefits to delaying construction. Should oil prices continue to rise at a rate greater than the prevailing rate of interest, the oil sands would be of greater value to Canadians if left in the ground than developed. Other possible benefits of holding *in situ* resources include a reduction in future extraction costs,[1]

[1] As the Cold Lake project is the first commercial venture of its type, improvements in technology resulting in a reduction of extraction costs may only come about by trial and error.

and the value of additional environmental amenities.

From a private perspective, delaying development has a number of associated problems. First, projects of the magnitude of the Cold Lake proposal take a number of years before finally coming on stream. Second, delaying construction increases the possibility of resource substitution. Finally, delays may threaten tenure security. Each of these factors result in increased risk to the private firm.

From a public perspective, delaying construction may have merit. Discoveries off the coast of Newfoundland and in the Beaufort Sea suggest that conventional sources of crude oil still remain to be discovered. Whether these discoveries can be developed at less cost per barrel than the Cold Lake deposits will depend on the size of the pools. Certainly the per barrel extraction costs will be less if a pool contains five hundred million barrels than if it contains five million barrels. Should these 'frontier' discoveries be as substantial as some indications suggest, greater reliance on these conventional sources of crude oil rather than the Cold Lake oil sands may be warranted.

The Alberta government is in a somewhat awkward position because of the importance of petroleum to that province's economy. The boom conditions Alberta has experienced over the past decade are directly related to the business activity generated by the oil industry. Decreasing petroleum exploration and development may result in

declining growth rates and increased unemployment--both politically unpopular. For that reason one could not expect the government of Alberta to favour any proposal which would reduce the role of the oil industry in that province. Nevertheless, slowing down the Albertan economy at this time may not be an entirely negative step.

While the Cold Lake project does appear economically viable, the environmental and social implications of the project should not be ignored. The long-term effects of sulphur emissions on the agricultural land base and the region's water resources are unknown. Similarly, the release of effluent into the Beaver River may, over a period of time, reduce the productivity and attractiveness of that water system. If irreversibilities are to be avoided and maximum levels of permissible environmental degradation established (e.g. a safe minimum standard of conservation), the policy instruments should be in place prior to plant operation.

The study has neglected the human aspects of proceeding with the Cold Lake development. A project of the scale proposed will undoubtedly result in some disruption of the small communities in the immediate vicinity of the development. How this disruption is viewed by individuals will depend on a number of socio-economic factors. Presumably the younger members of the business community would welcome such disturbances as along with them would come opportunities for business expansion. Older residents of these communities may see the development as the end of a way of life

and consequently oppose the project. These questions are more sociological than economic in nature and beyond the scope of this study. To residents of the region, however, the impact of the development on their lifestyle may be one of the more important issues. Unfortunately, as with many large projects, the only impacts some members of society will experience are negative impacts.

Beyond the question of economic feasibility is the question of how resource revenues are to be distributed. Prior to the federal budget of October 28, 1980, petroleum revenues were shared on a 10 percent, 45 percent, 45 percent basis among the federal government, the provincial government, and the oil companies, respectively. Under the new revenue sharing arrangement the provincial share is to decrease to 43 percent and the federal share of petroleum revenues is to increase substantially (to 24 percent), largely at the expense of the oil and gas companies. In conjunction with the new revenue sharing arrangement is a schedule of petroleum price increases designed to get the Canadian domestic price more in line with world levels. How the new revenue sharing and oil pricing schemes will affect incentives for exploration and development and Canada's goal of energy self-sufficiency is uncertain. Whether the oil companies will shift their operations to countries with more favourable economic arrangements or whether rising oil prices will compensate for revenues lost becuase of the new sharing arrangement remains a question

[illegible]

mark. One would assume that the federal government has considered both possibilities. The latter seems more reasonable.

At present no pricing agreement has been reached concerning new oil sands developments. The pricing impasse has put the future of the Alsands and Cold Lake developments in some doubt. Oil sands pricing is only part of the problem, however. Again the distributional question of "for whom" may be as important as "how much"? The pricing arrangements must satisfy all three interested parties (in the Cold Lake case) if the development is to proceed in the near future. One expects Imperial Oil to use its monopoly position with respect to the Cold Lake development to attempt to capture as much of the anticipated economic rent as possible.

The analysis of Chapter IV indicates that the Cold Lake oil sands project may not be as marginal as the study done for Imperial Oil suggests when the most recent information is taken into account. At $25.00 ($1979) per barrel of upgraded crude, the real internal rate of return was determined to be approximately 18 percent. Oil revenues would be shared among the developer and the federal and provincial governments. The results do suggest that the project may require only a minimum of public financial assistance, however.

While the selection of the discount rate is vital to the outcome of the benefit-cost analysis, the final choice often appears to be based on philosophical considerations.

A base discount rate of five to seven percent as this study deems appropriate can be criticized as strongly as the 10 percent base rate employed in the study undertaken for the developer. The discount rate considered to be most appropriate has implications for the extent to which public participation in the development is warranted. To reduce some of the conflicts inherent in discount rate selection in benefit-cost analyses, two suggestions are made: (1) the discount rate should be set for the analyst by the government concerned; and (2) where possible, more emphasis should be given the internal rate of return. Having a pre-determined discount rate would eliminate conflicts arising over the selection of a 'correct' rate of discount. Applying the internal rate of return will indicate the discount rate which equates the benefit and cost streams. Decision makers need only decide if the internal rate meets some particular threshold discount rate in making their economic decision. These suggestions will be workable only if the public sector is willing to accept more responsibility in project economic analyses.

A few comments should be made regarding the role of government in providing economic input in cases where public expenditure is expected to be substantial. As a general policy rule, social economic studies should be the responsibility of the government involved and not left up to the private developer. Greater public input into projects such as the Cold Lake scheme should pay dividends in terms of greater information and hence, improved decision making.

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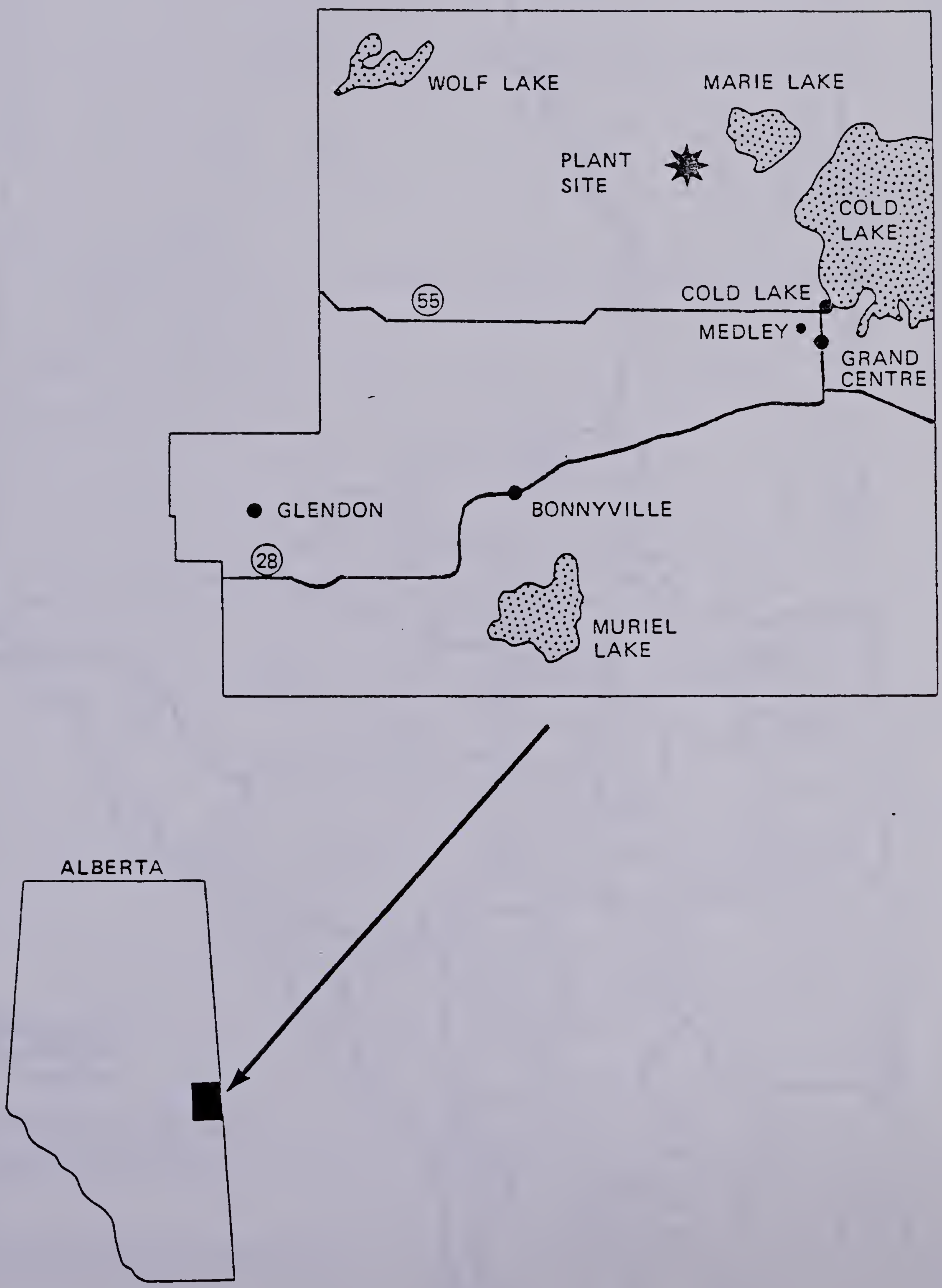
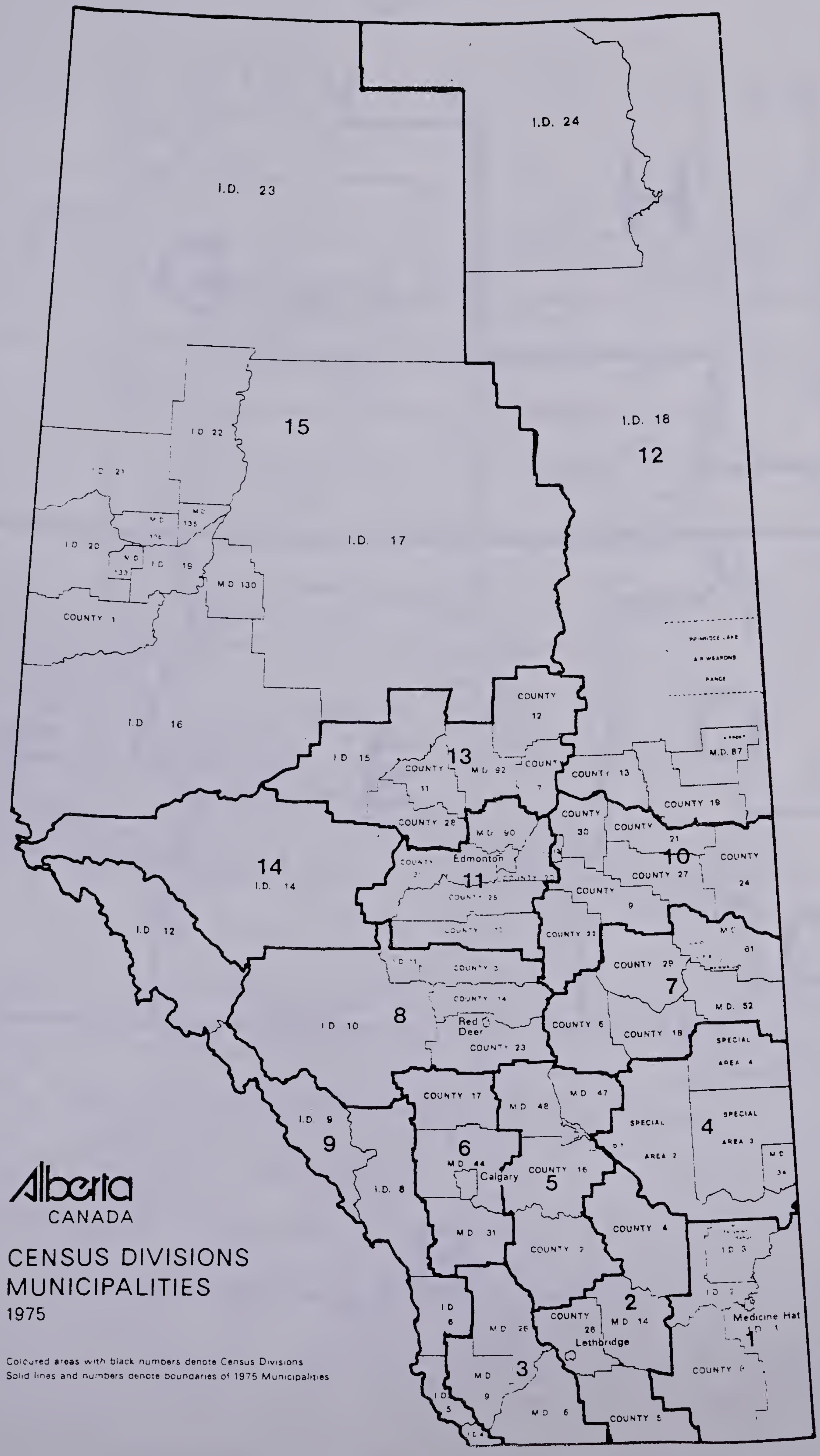
APPENDIX A

MAP 1

COLD LAKE STUDY AREA



MAP 2



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M.D. 130
COUNTY 1
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COUNTY 11
M.D. 92
COUNTY 13
M.D. 87
COUNTY 19
COUNTY 28
M.D. 90
COUNTY 30
14
I.D. 14
Edmonton
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COUNTY 25
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COUNTY 27
COUNTY 24
COUNTY 9
I.D. 12
COUNTY 22
COUNTY 29
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M.D. 52
COUNTY 14
8
I.D. 10
Red Deer
COUNTY 23
COUNTY 6
COUNTY 18
SPECIAL AREA 4
COUNTY 17
M.D. 48
M.D. 47
I.D. 9
9
6
M.D. 44
Calgary
COUNTY 16
5
SPECIAL AREA 2
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SPECIAL AREA 3
I.D. 8
COUNTY 4
M.D. 31
COUNTY 2
I.D. 3
2
M.D. 14
Lethbridge
Medicine Hat
I.D. 1
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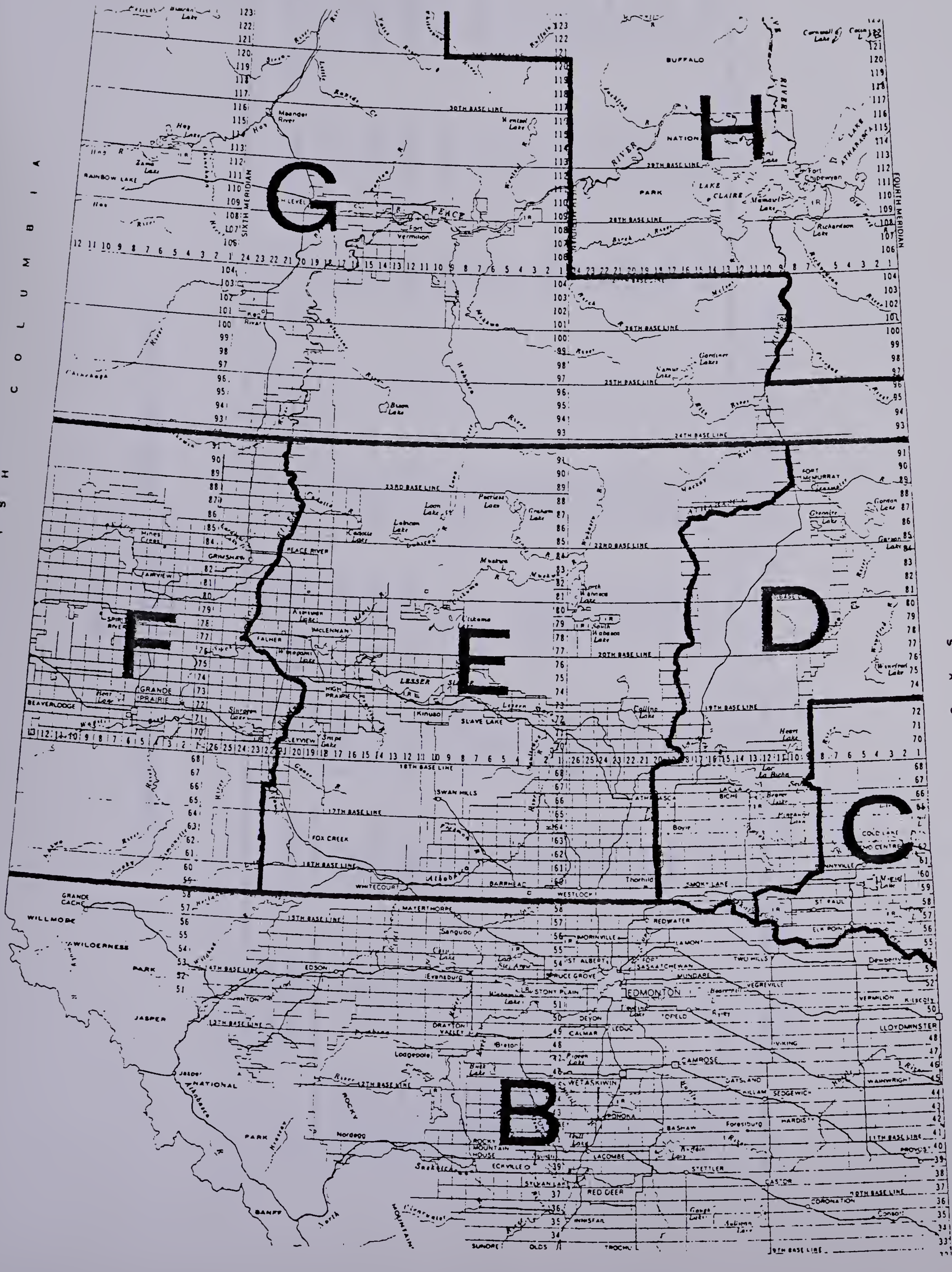
M.D. 26
3
M.D. 9
M.D. 6
COUNTY 5
Alberta
CANADA
CENSUS DIVISIONS
MUNICIPALITIES
1975
Coloured areas with black numbers denote Census Divisions
Solid lines and numbers denote boundaries of 1975 Municipalities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FOURTH MERIDIAN
EDMONTON
RED DEER
WETASKIWIN
CAMROSE
LLOYDMINSTER
WAINWRIGHT
VEGREVILLE
ST. ALBERT
FORT SASKATCHEWAN
SPRUCE GROVE
STONY PLAIN
DEVON
LEDUC
CALMAR
ATHABASCA
LAC LA BICHE
COLD LAKE
ST. PAUL
SMOKY LAKE
WESTLOCK
BARRHEAD
WHITECOURT
SWAN HILLS
FOX CREEK
SLAVE LAKE
HIGH PRAIRIE
McLENNAN
FALMER
PEACE RIVER
GRIMSHAW
FAIRVIEW
GRANDE PRAIRIE
BEAVERLODGE
SPIRIT RIVER
FORT McMURRAY
FORT CHIPEWYAN
FORT VERMILION
GRANDE CACHE
WILLMORE WILDERNESS PARK
JASPER
JASPER NATIONAL PARK
BANFF
ROCKY MOUNTAIN HOUSE
LACOMBE
STETTLER
CORONATION
OLDS
TROCHU
DRAYTON VALLEY
EDSON
BUFFALO NATIONAL PARK
LESSER SLAVE LAKE
LAKE CLAIRE

Table A.1.1

Commercial Fish Harvests (Selected Lakes)
Cold Lake
(lbs.)

Year	No. of Licenses	Suckers	Ling	Tullibee	Pike	Perch	Walleye	Trout	Whitefish
1967/68	125	750	10260	369000	5331	--	306	2777	127129
1968/69	78	2000	21127	419008	4086	--	673	3182	96625
1969/70	93	2000	11000	417188	3297	--	331	2357	99958
1970/71	53	5500	7500	--	1999	--	212	3060	77157
1971/72	65	5000	10000	--	2366	--	32	1767	99651
1972/73	43	150	5000	--	350	--	60	1286	61290
1973/74	56	1281	27218	129665	1803	--	133	5852	157453
1974/75	39	2187	28945	81742	3534	--	16	3527	102723
1975/76	34	1886	21293	92542	4899	--	95	4423	96288
1976/77	29	4768	15762	73325	3190	--	100	3887	87811
1977/78	23	1827	10216	63110	1127	--	59	4218	59135
1978/79	--	6155	11281	21000	554	--	91	2265	75648

Source: Energy and Natural Resources, Fish and Wildlife Division, Annual Harvest Data.

Table A.1.2

Ethel Lake
(lbs.)

Year	No. of Licenses	Suckers	Ling	Tullibee	Pike	Perch	Walleye	Trout	Whitefish
1967/68	8	225	550	4346	350	--	177	--	2698
1968/69	-	394	482	2880	159	--	20	--	1593
1969/70	-	--	--	--	--	--	--	--	--
1970/71	-	1000	--	6064	525	65	--	--	545
1971/72	-	--	--	--	--	--	--	--	--
1972/73	-	100	400	500	690	5	9	--	2167
1973/74	-	--	--	--	--	--	--	--	--
1974/75	-	20	359	155	284	--	18	--	4850
1975/76	1	1280	1135	70	1430	24	10	--	5130
1976/77	-	--	--	--	--	--	--	--	--
1977/78	-	770	354	64	918	--	62	--	5934
1978/79	-	--	--	--	--	--	--	--	--

Source: Energy and Natural Resources, Fish and Wildlife Division, Annual Harvest Data.

Table A.1.3

Marie Lake
(lbs.)

Year	No. of Licenses	Suckers	Ling	Tullibee	Pike	Perch	Walleye	Trout	Whitefish
1967/68									
1968/69									
1969/70									
1970/71									
1971/72	14	772	2883	--	33	--	17	--	14901
1972/73	4	202	685	--	42	--	23	--	8975
1973/74	3	691	1359	38	22	--	168	--	21432
1974/75	6	770	1640	--	85	--	175	--	17571
1975/76	2	361	618	--	4	--	31	--	5670
1976/77	--	45	1130	--	--	--	--	--	--
1977/78	--	--	50	--	--	--	--	--	440
1978/79	--	--	--	--	--	--	--	--	--

Source: Energy and Natural Resources, Fish and Wildlife Division, Annual Harvest Data.

Table A.1.4

Muriel Lake
(lbs.)

Year	No. of Licenses	Suckers	Ling	Tullibee	Pike	Perch	Walleye	Trout	Whitefish
1967/68	73	12127	7041	--	204	21	11	--	28428
1968/69	4	--	1005	--	194	--	--	--	64524
1969/70	17	7500	1200	--	55	--	--	--	52442
1970/71	22	4485	--	--	120	--	--	--	47220
1971/72	26	2955	1700	--	673	--	--	--	63640
1972/73	22	9675	219	--	1895	--	--	--	67075
1973/74	11	7400	--	--	960	--	--	--	32638
1974/75	11	873	3216	--	2133	--	43	--	73443
1975/76	16	3531	2596	--	2930	--	50	--	89219
1976/77	5	1530	423	--	2880	--	6	--	58164
1977/78	8	2686	1872	--	4214	--	9	--	43443
1978/79	--	4188	574	--	4827	--	--	--	64814

Source: Energy and Natural Resources, Fish and Wildlife Division, Annual Harvest Data.

Table A.1.5

Moose Lake
(lbs.)

Year	No. of Licenses	Suckers	Ling	Tullibee	Pike	Perch	Walleye	Trout	Whitefish
1967/68	27	3217	9518	23820	185	30	688	--	17350
1968/69	4	--	--	44674	1202	--	1497	--	19531
1969/70	5	1200	6593	54688	1615	10	1069	--	8704
1970/71	3	920	4219	23800	3504	--	4000	--	7654
1971/72	--	1200	4327	5735	1198	6	2814	--	5600
1972/73	--	500	750	1000	972	--	275	--	8147
1973/74	--	2290	2300	4676	851	190	871	--	13559
1974/75	2	150	600	1504	435	--	330	--	23457
1975/76	--	125	330	--	280	--	140	--	27293
1976/77	4	697	239	750	513	--	973	--	25186
1977/78	2	340	90	448	640	--	2539	--	42286
1978/79	--	150	400	1952	1120	--	1026	--	40485

Source: Energy and Natural Resources, Fish and Wildlife Division, Annual Harvest Data.

Table A.1.6

Wolf Lake
(lbs.)

Year	No. of Licenses	Suckers	Ling	Tullibee	Pike	Perch	Walleye	Trout	Whitefish
1967/68	22	5200	3448	49307	22198	--	2985	--	9268
1968/69	8	7942	983	34923	25182	123	10605	--	8510
1969/70	3	18509	6649	18823	15033	58	13072	--	4582
1970/71	2	5942	1990	1550	44928	100	4718	--	3017
1971/72	7	6962	3405	--	11893	--	3220	--	3284
1972/73	2	5582	4091	110	14468	--	1289	--	7024
1973/74	4	2694	4320	58	7484	--	2007	--	10477
1974/75	23	1325	3620	65	6018	--	2881	--	9595
1975/76	--	17252	6144	569	6426	--	2393	--	20097
1976/77	--	17404	3168	1631	10811	--	2719	--	16815
1977/78	3	16124	1478	578	14579	--	2214	--	16892
1978/79	--	24391	2585	568	11943	--	2679	--	19066

Source: Energy and Natural Resources, Fish and Wildlife Division, Annual Harvest Data.

Table A.1.7

Frog Lake
(lbs.)

Year	No. of Licenses	Suckers	Ling	Tullibee	Pike	Perch	Walleye	Trout	Whitefish
1967/68	8	12600	200	-	4720	-	-	-	150300
1968/69	-	14430	-	-	2235	-	-	-	74600
1969/70	-	15425	-	-	4282	30	54	-	122847
1970/71	-	3665	-	-	2690	142	55	-	23540
1971/72	-	6300	200	-	5266	-	266	-	76838
1972/73	-	10147	-	-	53153	82	493	-	28074
1973/74	-	9600	200	-	8290	60	16	-	71675
1974/75	-	6750	-	-	4270	-	111	-	68130
1975/76	-	3750	530	-	12960	140	680	-	57767
1976/77	1	--	625	-	4415	30	60	-	50060
1977/78	-	1400	350	-	1280	-	6	-	19100
1978/79	-	6400	800	-	16513	-	775	-	12510

Source: Energy and Natural Resources, Fish and Wildlife Division, Annual Harvest Data.

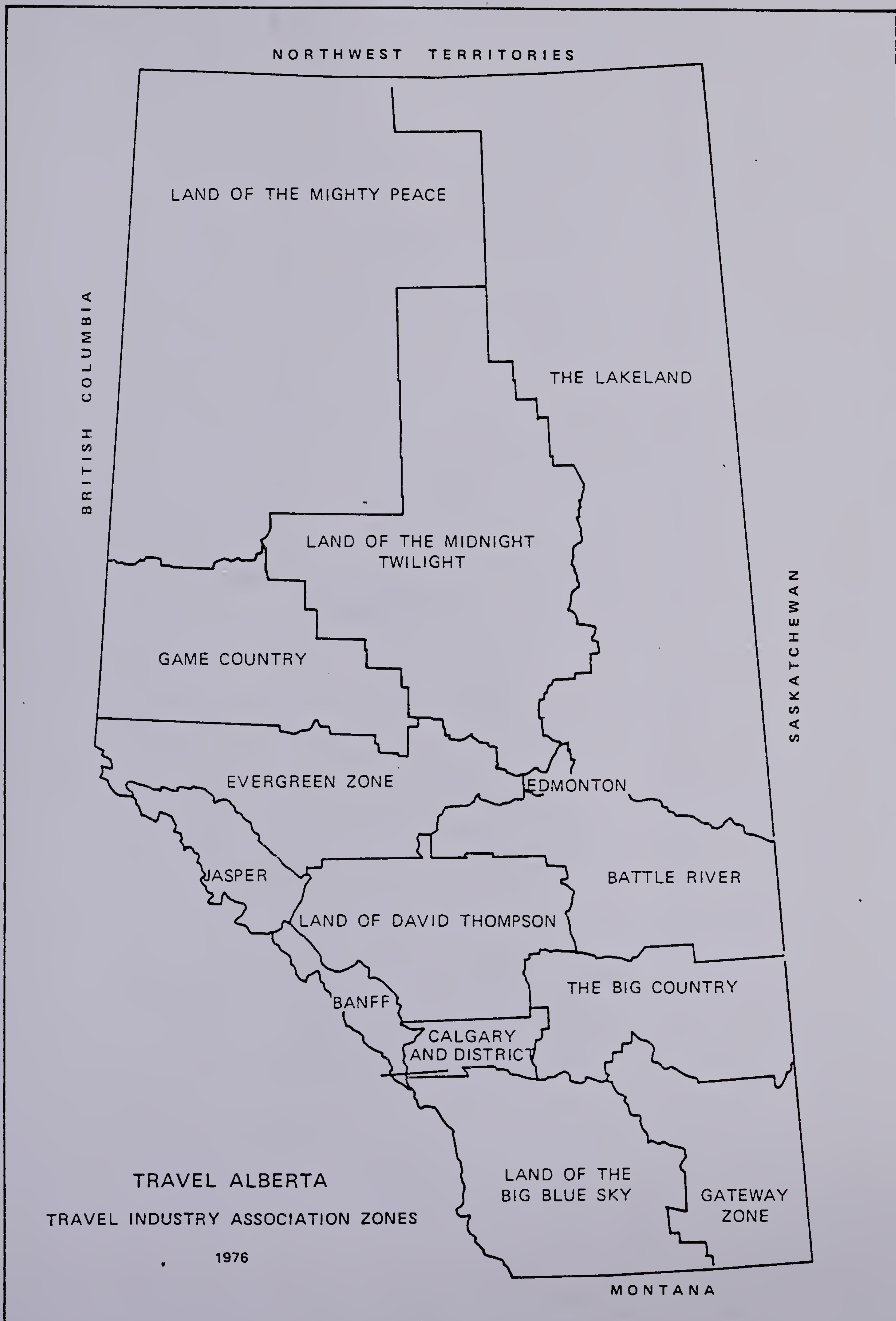
Table A.2

Average Pelt Price in Alberta, 1975 - 1979

	1975/76	1976/77	1977/78	1978/79
Badger	25.87	42.56	53.60	78.85
Beaver	17.52	22.14	18.10	32.10
Bobcat	86.00	146.09	199.00	314.40
Coyote	50.00	59.47	57.90	95.50
Ermine/Weasel	1.12	1.00	1.70	1.90
Fisher	65.94	84.18	83.50	124.20
Fox (Cross)	73.35	86.05	92.45	169.55
Fox (Red)	49.78	57.44	63.20	119.75
Fox (Silver)	46.41	56.25	62.10	112.50
Lynx	227.90	254.64	281.55	311.45
Marten	21.33	24.36	23.10	37.20
Mink	17.69	24.48	20.60	27.95
Muskrat	3.31	4.15	4.15	5.25
Otter	58.49	66.04	56.80	86.75
Rabbit	.55	.40	.50	N/A
Raccoon	20.26	29.28	32.80	42.00
Skunk	1.50	2.00	1.50	7.55
Squirrel	.80	.74	1.55	2.30
Wolf	75.80	81.56	89.30	124.30
Wolverine	162.86	173.19	153.95	183.85

Source: Annual Reports, Alberta Recreation Parks and Wildlife, various years.

MAP 4


NORTHWEST TERRITORIES
BRITISH COLUMBIA
SASKATCHEWAN
MONTANA
LAND OF THE MIGHTY PEACE
THE LAKELAND
LAND OF THE MIDNIGHT TWILIGHT
GAME COUNTRY
EVERGREEN ZONE
EDMONTON
JASPER
BATTLE RIVER
LAND OF DAVID THOMPSON
THE BIG COUNTRY
BANFF
CALGARY AND DISTRICT
LAND OF THE BIG BLUE SKY
GATEWAY ZONE
TRAVEL ALBERTA
TRAVEL INDUSTRY ASSOCIATION ZONES
1976

APPENDIX B

Table B.1

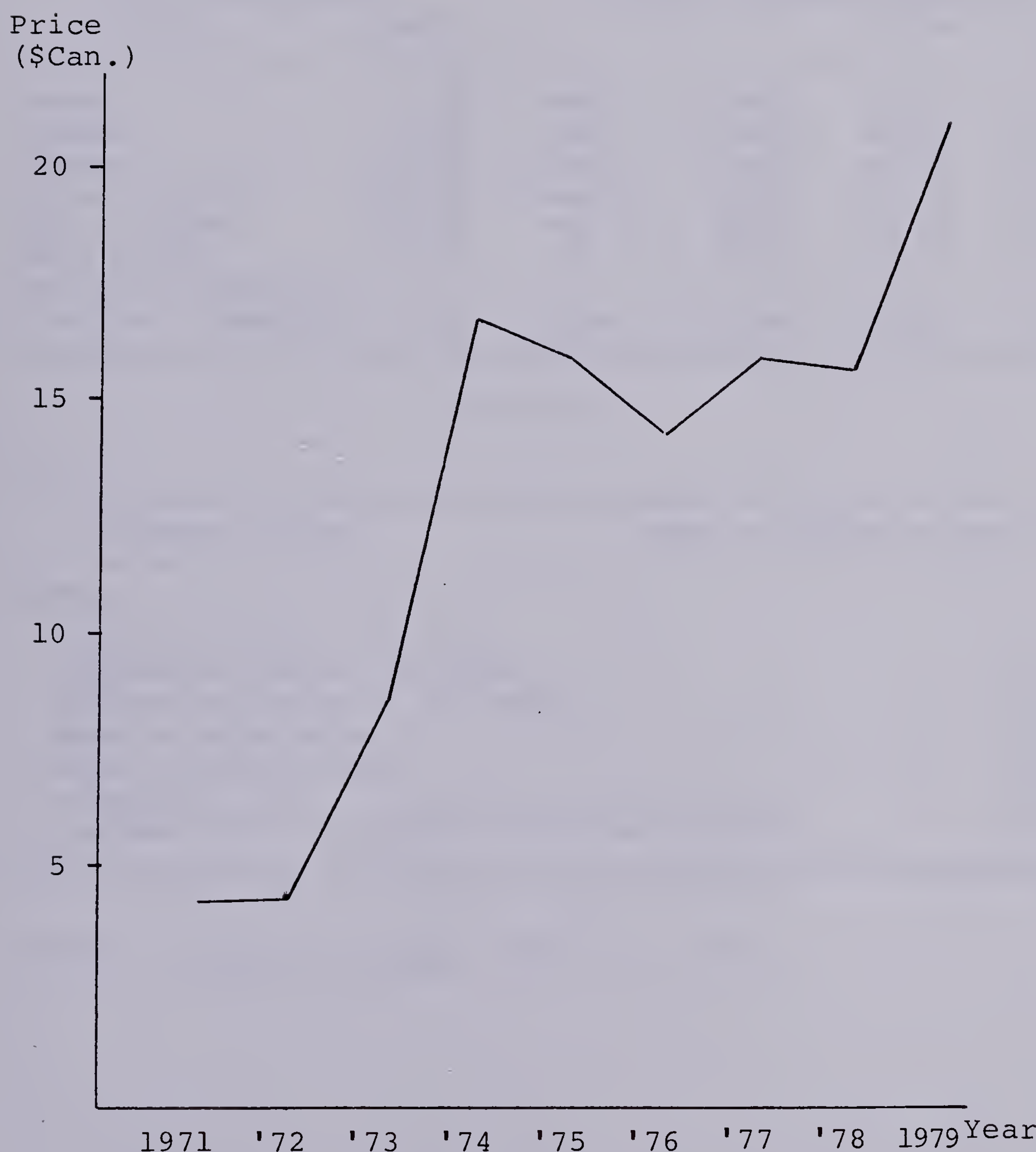
Resource Use Compatibility Matrix

Categories	Oil Sands Development	Provincial Parks	Non-Consumptive Tourism	Trapping	Commercial Fishing	Sport Hunting & Fishing	Agriculture	Forestry
Forestry	Incompatible -may be able to reforest after use	Incompatible	Compatible	Compatible	Compatible	Compatible	Compatible	
Agriculture	Incompatible -reclaimation may eventually restore productivity of land	Incompatible	Compatible	Incompatible	Compatible	Compatible		
Sport Hunting and Fishing	Incompatible	Incompatible	Compatible	Compatible	Compatible			
Commercial Fishing	Compatible	Incompatible	Compatible	Compatible				
Trapping	Incompatible -disrupt wildlife habitat	Incompatible	Compatible					
Non-Consumptive Tourism	Incompatible -adversely affects scenic attractions	Compatible						
Provincial Parks	Incompatible							

APPENDIX C

Figure C.1

Per Barrel Price of Saudi Arabian Crude
1971 - 1979
(1979 = 100)



Source: Petroleum Economist, various years.

Table C.1

Selected Rates of Return in the Canadian Economy

Bond Quotations		Week to Thursday April 17		
Issues	Coupon		Price	Yield
Canada	4.50	Sept. 1, 1983	79.50	12.03
Canada	9.75	Feb. 1, 1984	91.00	12.82
Canada	10.00	May 1, 2002	81.50	12.48
Ontario Hydro	10.00	May 9, 2009	79.00	12.75
Hydro-Quebec	10.25	May 15, 2003	78.87	13.20
Bell Canada	9.85	Oct. 15, 2005	76.75	13.00
Canadian Imperial Bank of Commerce	10.10	June 15, 1984	89.00	13.65

****

Interest Rates	Week to Thursday April 17
Canada	
Treasury Bills (91 days)	15.71
Commercial Paper (90 days)	16.25
Bankers Acceptance (90 days)	16.05
Bank's Prime Rate	17.25
Bank of Canada Rate	15.96
Morgages	17.50
Average Yield Long-Term Government Bonds	12.40

Source: Financial Times, April 21, 1980.

Table C.2

Cold Lake Project Cost and Revenue Streams
(million 1977 dollars)

Year	Revenue	Operating Cost	Capital Cost
1980			120
1981			243
1982			564
1983			945
1984			790
1985			475
1986	360	109	212
1987	673	204	54
1988 - 2010	748	227	88
Total	18,241	5,522	5,414

Source: Foster Research. Cost-Benefit Analysis of the Cold Lake Oil Sands Project, 1978.

Table C.3.1

Economic Evaluation of Cold Lake Oil Sands Project
Oil Price $13.00/barrel
($1979)

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	2.70	1.22	1.15	1.09	1.03	.97	.92
	NB*	6354	1690	1063	564	166	-150	-403
	IRR	7.5						
1%	B/C	3.39	1.353	1.275	1.2	1.129	1.061	.997
	NB	8931	2742	1915	1258	735	318	-15
	IRR	8.95						
3%	B/C	5.14	1.69	1.578	1.472	1.372	1.279	1.192
	NB	15460	5356	4022	2965	2126	1457	922
	IRR	11.52						
5%	B/C	7.54	2.14	1.98	1.83	1.692	1.563	1.445
	NB	24418	8853	6824	5221	3951	2942	2136
	IRR	13.82						
7%	B/C	10.85	2.747	2.519	2.308	2.114	1.937	1.775
	NB	36756	13566	10576	8224	6367	4894	3722
	IRR	15.96						
9%	B/C	15.42	3.569	3.245	2.948	2.677	2.432	2.21
	NB	53809	19950	15632	12247	9584	7479	5810
	IRR	17.97						

*Net Benefits are in million 1979 dollars.

Table C.3.2

Oil Price $14.50/barrel
($1979)

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	3.30	1.36	1.29	1.22	1.15	1.08	1.02
	NB	8599	2784	1991	1356	847	437	107
	IRR	9.37						
1%	B/C	4.07	1.51	1.423	1.339	1.259	1.184	1.112
	NB	11474	3959	2943	2132	1482	959	539
	IRR	10.71						
3%	B/C	6.03	1.885	1.76	1.642	1.531	1.427	1.33
	NB	18761	6874	5293	4036	3033	2230	1585
	IRR	13.13						
5%	B/C	8.71	2.388	2.209	2.042	1.887	1.744	1.612
	NB	28754	10777	8419	6553	5070	3887	2939
	IRR	15.34						
7%	B/C	12.40	3.065	2.81	2.575	2.359	2.161	1.981
	NB	42522	16035	12606	9904	7765	6065	4708
	IRR	17.40						
9%	B/C	17.50	3.982	3.621	3.289	2.987	2.713	2.466
	NB	615.47	23158	18246	14392	11355	8950	7038
	IRR	19.37						

Table C.3.3

Oil Price $16.00/barrel

i / ΔP/yr.		0%	4%	5%	6%	7%	8%	9%
0%	B/C	3.91	1.5	1.42	1.34	1.27	1.2	1.12
	NB	10843	3867	2910	2141	1520	1018	610
	IRR	11.06						
1%	B/C	4.76	1.660	1.57	1.478	1.39	1.306	1.227
	NB	14019	5174	3970	3004	2227	1600	1092
	IRR	12.31						
3%	B/C	6.91	2.081	1.943	1.812	1.69	1.575	1.468
	NB	22059	8392	6564	5106	3940	3002	2247
	IRR	14.61						
5%	B/C	9.87	2.635	2.438	2.254	2.083	1.925	1.779
	NB	33086	12699	10014	7884	6188	4831	3741
	IRR	16.73						
7%	B/C	13.94	3.383	3.102	2.842	2.603	2.385	2.186
	NB	48281	18503	14635	11582	9162	7235	5694
	IRR	18.75						
9%	B/C	19.57	4.395	3.996	3.63	3.297	2.994	2.721
	NB	69283	26364	30861	16537	13124	10419	8266
	IRR	20.67						

Table C.3.4

Oil Price $17.50/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	4.51	1.64	1.55	1.47	1.39	1.31	1.23
	NB	13087	4962	3839	2934	2201	1605	1119
	IRR	12.59						
1%	B/C	5.44	1.823	1.718	1.617	1.52	1.429	1.343
	NB	16559	6389	4996	3877	2973	2241	1646
	IRR	13.78						
3%	B/C	7.80	2.276	2.125	1.982	1.848	1.723	1.606
	NB	25356	9910	7834	6177	4847	3775	2908
	IRR	15.98						
5%	B/C	11.03	2.883	2.667	2.466	2.279	2.106	1.946
	NB	37424	14622	11609	9215	7306	5775	4544
	IRR	18.05						
7%	B/C	15.48	3.7	3.393	3.109	2.848	2.609	2.391
	NB	54044	20971	16664	13261	10560	8406	6680
	IRR	20.01						
9%	B/C	21.64	4.808	4.371	3.971	3.607	3.276	2.977
	NB	77016	39571	23475	18681	14894	11889	9493
	IRR	21.90						

Table C.3.5

Oil Price $19.00/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	5.11	1.78	1.69	1.59	1.51	1.42	1.34
	NB	15331	6055	4767	3726	2881	2182	1628
	IRR	14.02						
1%	B/C	6.12	1.979	1.865	1.755	1.651	1.552	1.458
	NB	19101	7605	6023	4749	3719	2882	2199
	IRR	15.14						
3%	B/C	8.68	2.471	2.308	2.153	2.007	1.871	1.744
	NB	28653	11427	9105	7247	5753	4548	3570
	IRR	17.27						
5%	B/C	12.19	3.13	2.896	2.677	2.474	2.286	2.113
	NB	41757	16544	13203	10547	8424	6720	5346
	IRR	19.28						
7%	B/C	17.03	4.018	3.685	3.376	3.093	2.833	2.596
	NB	59806	23439	18693	14940	11957	9576	7666
	IRR	21.20						
9%	B/C	23.71	5.221	4.747	4.312	3.916	3.557	3.233
	NB	84752	32778	28676	22948	18416	14813	10721
	IRR	23.06						

Table C.3.6

Oil Price $20.50/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	5.70	1.92	1.82	1.72	1.62	1.53	1.44
	NB	17553	7149	5696	4519	3561	2779	2137
	IRR	15.34						
1%	B/C	6.79	2.134	2.011	1.893	1.78	1.673	1.572
	NB	21615	8809	7041	5614	4458	3517	2748
	IRR	16.42						
3%	B/C	9.55	2.665	2.488	2.321	2.164	2.017	1.88
	NB	31920	12931	10363	8307	6652	5313	4226
	IRR	18.49						
5%	B/C	13.34	3.376	3.123	2.887	2.668	2.465	2.279
	NB	46047	18448	14783	11865	9531	7655	6141
	IRR	20.44						
7%	B/C	18.56	4.333	3.973	3.641	3.335	3.055	2.8
	NB	65509	24882	20702	16602	13341	10735	8643
	IRR	22.33						
9%	B/C	25.77	5.629	5.118	4.65	4.223	3.836	3.486
	NB	92408	35952	28676	22948	18416	14813	11936
	IRR	24.15						

Table C.3.7

Oil Price $22.00/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	6.31	2.06	1.95	1.84	1.74	1.64	1.55
	NB	19798	8233	6616	5304	4235	3360	2642
	IRR	16.59						
1%	B/C	7.48	2.291	2.159	2.032	1.911	1.796	1.688
	NB	24163	10025	8068	6487	5204	4158	3302
	IRR	17.64						
3%	B/C	10.44	2.861	2.671	2.492	2.323	2.165	2.018
	NB	35216	14449	11635	9378	7559	6086	4889
	IRR	19.65						
5%	B/C	14.50	3.623	3.352	3.099	2.864	2.464	2.446
	NB	50380	20371	16378	13197	10650	8600	6944
	IRR	21.56						
7%	B/C	20.10	4.651	4.265	3.908	3.579	3.279	3.005
	NB	71273	28350	22731	18281	14739	11906	9629
	IRR	23.41						
9%	B/C	27.84	6.042	5.494	4.991	4.533	4.117	3.741
	NB	100142	39159	31291	25093	20186	16283	13164
	IRR	25.21						

Table C.3.8

Oil Price $23.50/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	6.91	2.2	2.08	1.97	1.86	1.76	1.66
	NB	22042	9325	7543	6095	4914	3946	3150
	IRR	17.78						
1%	B/C	8.16	2.447	2.306	2.171	2.041	1.919	1.803
	NB	26703	11240	9095	7360	5950	4799	3856
	IRR	18.80						
3%	B/C	11.32	3.056	2.853	2.662	2.482	2.313	2.156
	NB	38517	15967	12905	10448	8466	6859	5551
	IRR	20.75						
5%	B/C	15.66	3.871	3.581	3.311	3.059	2.827	2.623
	NB	54716	22294	17973	14528	11768	9545	7747
	IRR	22.63						
7%	B/C	21.65	4.968	4.556	4.175	3.824	3.503	3.211
	NB	77035	30818	24760	19960	16136	13076	10615
	IRR	24.45						
9%	B/C	29.91	6.455	5.869	5.332	4.842	4.398	3.997
	NB	107878	42366	33905	27237	21956	17753	14392
	IRR	26.22						

Table C.3.9

Oil Price $25.00/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	7.51	2.34	2.22	2.1	1.98	1.87	1.76
	NB	24287	10420	8472	6888	5595	4533	3659
	IRR	18.91						
1%	B/C	8.84	2.604	2.454	2.31	2.172	2.041	1.918
	NB	29246	12456	10122	8233	6696	5441	4410
	IRR	19.90						
3%	B/C	12.21	3.252	3.036	2.832	2.64	2.461	2.294
	NB	41815	17485	14176	11519	9373	7632	6213
	IRR	21.81						
5%	B/C	16.83	4.118	3.81	3.523	3.255	3.008	2.78
	NB	59054	24217	19568	15860	12886	10490	8549
	IRR	23.65						
7%	B/C	23.19	5.286	4.848	4.442	4.069	3.727	3.416
	NB	82798	33287	26790	21639	17534	14247	11602
	IRR	25.44						
9%	B/C	31.99	6.868	6.245	5.673	5.152	4.68	4.253
	NB	115617	45573	36520	29382	23726	19223	15620
	IRR	27.19						

Table C.3.10

Oil Price $26.50/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	8.11	2.48	2.35	2.22	2.1	1.98	1.87
	NB	26531	11514	9401	7681	6275	5121	4168
	IRR	19.99						
1%	B/C	9.52	2.76	2.601	2.448	2.302	2.164	2.034
	NB	31792	13672	11149	9106	7442	6081	4963
	IRR	20.96						
3%	B/C	13.09	3.447	3.218	3.002	2.799	2.609	2.432
	NB	45113	19003	15447	12589	10280	8405	6875
	IRR	22.83						
5%	B/C	17.99	4.366	4.039	3.734	3.451	3.189	2.947
	NB	63388	26140	21163	17191	14004	11434	9352
	IRR	24.64						
7%	B/C	24.74	5.604	5.139	4.709	4.313	3.951	3.621
	NB	88559	35755	28819	23318	18932	15418	12588
	IRR	26.40						
9%	B/C	34.06	7.281	6.62	6.014	5.462	4.961	4.508
	NB	123350	48780	39134	31526	25496	20693	16847
	IRR	28.12						

Table C.3.11

Oil Price $28.00/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	8.71	2.62	3.48	2.35	2.22	2.09	1.97
	NB	28753	12597	10320	8466	6949	5702	4672
	IRR	21.02						
1%	B/C	10.19	2.916	2.747	2.586	2.432	2.286	2.148
	NB	34306	14876	12166	9970	8181	6717	5512
	IRR	2'.96						
3%	B/C	13.97	3.641	3.399	3.171	2.956	2.755	2.568
	NB	48377	20506	16705	13649	11178	9170	7531
	IRR	23.80						
5%	B/C	19.14	4.611	4.266	3.944	3.645	3.368	3.113
	NB	67676	28043	22742	18509	15111	12370	10147
	IRR	25.58						
7%	B/C	26.26	5.919	5.427	4.973	4.555	4.173	3.825
	NB	94262	38198	30828	24980	20316	16577	13564
	IRR	27.31						
9%	B/C	36.11	7.69	6.992	6.352	5.769	5.24	4.761
	NB	131003	51954	41721	33649	27248	22148	18063
	IRR	29.02						

Table C.3.12

Oil Price $29.50/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	9.30	2.76	2.62	2.47	2.34	2.2	2.08
	NB	30975	13692	11249	9259	7629	6289	5181
	IRR	22.01						
1%	B/C	10.87	3.07	2.89	2.72	2.56	2.41	2.26
	NB	36822	16080	13184	10835	8920	7352	6060
	IRR	22.93						
3%	B/C	14.84	3.83	3.58	3.34	3.11	2.9	2.7
	NB	51641	22009	17964	14708	12076	9936	8187
	IRR	24.73						
5%	B/C	20.29	4.86	4.49	4.15	3.84	3.55	3.28
	NB	71967	29947	24321	19828	16219	12305	10942
	IRR	26.49						
7%	B/C	27.79	6.23	5.72	5.24	4.8	4.39	4.03
	NB	99965	40641	32836	26642	21699	17736	14541
	IRR	28.20						
9%	B/C	38.16	8.1	7.36	6.69	6.08	5.52	5.01
	NB	138658	55127	44308	35771	29000	23603	19278
	IRR	29.88						

Table C.3.13

Oil Price $31.00/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	9.90	2.9	2.75	2.6	2.45	2.32	2.18
	NB	33219	14785	12177	10051	8309	6875	5690
	IRR	22.97						
1%	B/C	11.55	3.23	3.04	2.86	2.69	2.53	2.38
	NB	39365	17295	14210	11708	9666	7993	6614
	IRR	23.87						
3%	B/C	15.72	4.03	3.76	3.51	3.27	3.05	2.84
	NB	54941	23527	19234	15779	12983	10709	8849
	IRR	25.64						
5%	B/C	21.45	5.1	4.72	4.37	4.03	3.73	3.45
	NB	76301	31869	25916	21159	17337	14250	11744
	IRR	27.37						
7%	B/C	29.34	6.55	6.01	5.5	5.04	4.62	4.23
	NB	105726	43109	34865	28321	23097	18806	15527
	IRR	29.06						
9%	B/C	40.24	8.51	7.74	7.03	6.38	5.8	5.27
	NB	146396	58324	46922	37916	30770	25072	20506
	I E	30.73						

Table C.3.14

Oil Price $32.50/barrel

i / ΔP/yr.		0%	4%	5%	6%	7%	8%	9%
0%	B/C	10.51	3.04	2.88	2.72	2.57	2.43	2.29
	NB	35464	15879	13105	10844	8990	7463	6199
	IRR	23.89						
1%	B/C	12.23	3.38	3.19	3.0	2.82	2.65	2.49
	NB	41908	18511	15238	12581	10413	8634	7168
	IRR	24.78						
3%	B/C	16.61	4.23	3.94	3.68	3.43	3.2	2.98
	NB	58238	25046	20506	16850	13890	11482	9512
	IRR	26.53						
5%	B/C	22.61	5.35	4.95	4.58	4.23	3.91	3.61
	NB	80634	33792	27512	22491	18455	15195	12547
	IRR	28.23						
7%	B/C	30.88	6.87	6.3	5.77	5.29	4.84	4.44
	NB	111488	45578	36895	30000	24495	20077	16513
	IRR	29.90						
9%	B/C	42.31	8.92	8.11	7.37	6.69	6.08	5.53
	NB	154132	61541	49537	40061	32540	26542	21734
	IRR	31.55						

Table C.3.15

Oil Price $34.00/barrel

ΔP/yr. \ i		0%	4%	5%	6%	7%	8%	9%
0%	B/C	11.10	3.18	3.01	2.85	2.69	2.54	2.4
	NB	37686	16963	14025	11629	9664	8044	6703
	IRR	24.78						
1%	B/C	12.91	3.54	3.33	3.14	2.95	2.77	2.61
	NB	44429	19715	16255	13446	11152	9269	7717
	IRR	25.66						
3%	B/C	17.48	4.42	4.13	3.85	3.59	3.34	3.12
	NB	61505	26549	21764	17910	14789	12247	10168
	IRR	27.37						
5%	B/C	23.76	5.6	5.18	4.79	4.42	4.09	3.78
	NB	84925	35696	29091	23809	19562	16130	13342
	IRR	29.06						
7%	B/C	32.41	7.18	6.59	6.04	5.53	5.07	4.64
	NB	117191	48020	38904	31662	25879	21236	17490
	IRR	30.71						
9%	B/C	44.36	9.33	8.49	7.71	7.0	6.36	5.78
	NB	161787	64715	52125	42183	34293	27997	22950
	IRR	32.34						